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SETTING YOUR SIGHTS ON THE SUN

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A PALO ALTO GUIDE TO SOLAR ENERGY USE

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Palo Alto Encourages Solar Energy

by Rick McClure

This innovative utility course of action was made possible because of widespread community belief that a Municipal Utility's responsibility goes beyond a normal utility-customer relationship.

Eighty years ago Palo Alto residents complained about the unreliable and expensive (20¢ per kilowatt hour!) electric services available. In response, the town of Palo Alto opened an electric generating plant to serve the community with a full range of utility services. The new municipal electric service proved reliable and reduced customer costs by 50%. Today, the City and its Municipal Utilities Department continue to work to provide all its residents, businesses and industries with a full range of reliable and competitively priced energy services.

In 1973, the actions of Organization of Petroleum Exporting Countries (OPEC) raised urgent questions regarding the continued availability of the inexpensive energy resources that Palo Alto residents relied upon for their comfort and employment. To insure the energy future of their community, Palo Alto City Council created a citizens committee to study the long-term energy needs of the community. In 1975 the City Council acted on this committee's recommendation to establish a Resource Conservation Program in the Municipal Utilities Department. A major utility effort to tap local energy conservation and solar energy resources was seen as capable of reducing the community's future natural gas and electricity requirements. Such a program would not only bring immediate energy bill reductions to consumers adopting the use of conservation and solar energy, but could also minimize the utility bills of all customers.

This innovative utility course of action was made possible in Palo Alto, in large measure, due to a widespread community belief that the Municipal Utilities' particular responsibilities to its customers extend beyond a normal utility-customer relationship. The City not only recognized that solar and conservation could be dependable and low cost energy supply options, but also that a new relationship between the utility, its customers and the local business community could be established. Natural gas and electric services had always been available to the homes and businesses of utility customers with only a flip of a switch. However, the installation of conservation and solar energy technologies is much more complex and involves the active participation of the customer and the services of the private sector. The ability of a municipal utility to work well with both its customers and with the business community will largely ▶

Rick McClure is the Coordinator of the Solar Programs for the City of Palo Alto Municipal Utilities Department. Previously he worked for the California Energy Commission Solar Office.

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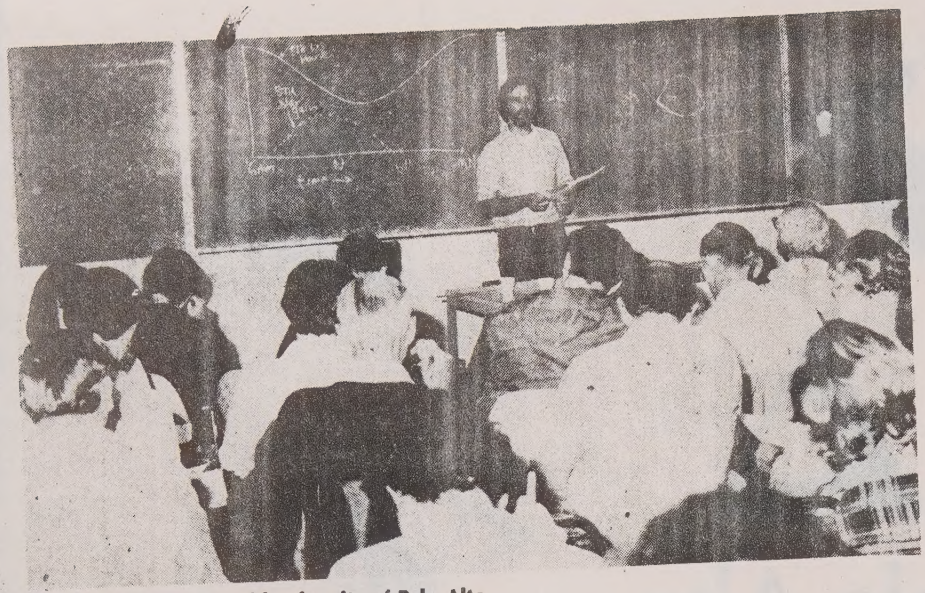


Solar Classes sponsored by the city of Palo Alto

spell the success or failure of the municipal utility in attaining its conservation and solar program goals. Thus, when the Palo Alto City Council authorized the initiation of the Resource Conservation & Solar Programs, it was not restating the bleakness of our nation's energy supply options, but was reaffirming its faith that its municipal utility, its customers and the private sector could work together in an innovative and successful partnership to the long-term benefit of the entire community.

Summary of the City of Palo Alto Solar Program

The City's Solar Energy Program has been designed with the active participation of the utilities customers and the local solar industry. Open public meetings were held throughout 1979 and 1980 to determine the public's reaction to increasing solar energy use in Palo Alto. These meetings assisted the City in preparing its outline of solar program activities. In 1980, the Utilities Department surveyed customers from single-family dwellings, multiple-family buildings, and commercial/industrial complexes to ascertain the attitudes of these customers concerning the use of solar energy in their homes or businesses. With these surveys, the City refined the details of the solar program efforts.

In 1980, the Solar Program prepared its first technical document, *Solar System Design and Installation Standards*, for the proposed solar financing program. Drafts of this technical document were sent to all known solar businesspersons in the area (75 companies) and were the subject of a series of joint utility/industry work sessions. This process enabled the City to devise a solar energy program that meets the perceived needs of the community in a manner consistent with standard good quality industry design and installation practices. As community acceptance and use of solar energy increases, and as applicable innovations are made in the solar industry, the City of Palo Alto Solar Program will be revised to reflect these changes. The Palo Alto Solar Program will not merely record change, but by continuing to work in partnership with utility customers and the solar industry, it perceives itself as playing an active role in an evolving solar community.

Today, the initial Palo Alto Solar Program has three areas of emphasis:

—Public education and consumer assurance services for all utility customers

—Low interest financing for solar installations.

—Modification of Utility Rules and City Regulations to encourage appropriate uses of solar energy.

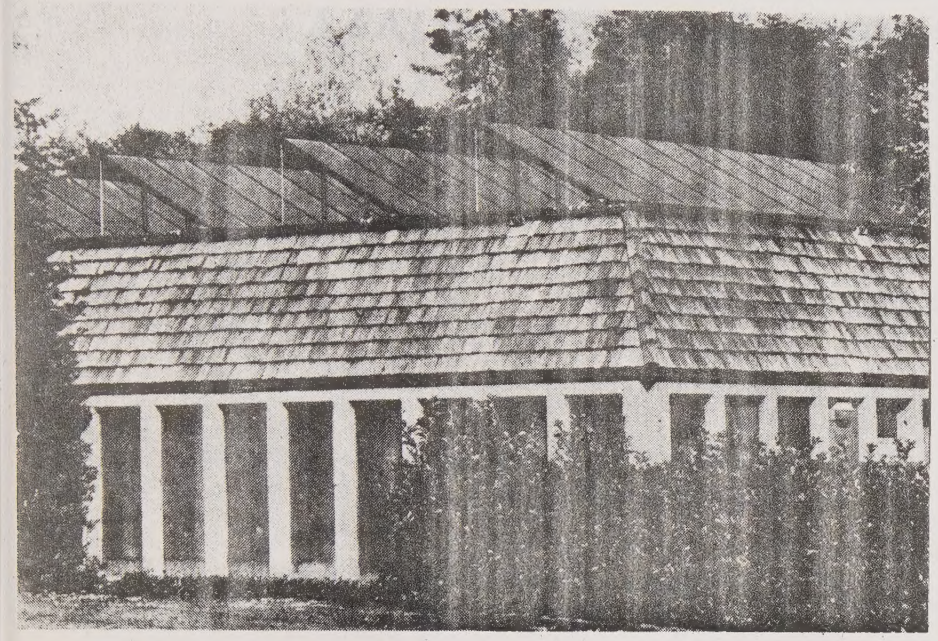
Each of these three efforts is briefly discussed below.

Public Education/Consumer Assurance Services. The Palo Alto Solar Program is interested in expanding the solar marketplace to include customers who are not currently considering the purchase of a solar system. A certain number of City residents can be expected to install a solar system, regardless of the research effort required to become knowledgeable consumers. Most consumers, however, will neither gamble on a $3,000 investment, nor devote evenings and weekends to educating themselves about solar energy. Yet, potential solar consumers today are generally expected to perform such independent research or to "gamble" on a purchase with limited knowledge.

The Palo Alto Municipal Utilities Department hopes to reduce the problems that potential solar consumers face with comprehensive public education services. Information on practical uses of solar energy (specific to Palo Alto) will be made available to all utility customers. Briefly, this information will be made available through 1) a series of one and two page fact sheets, 2) a telephone "hot line" consultation service staffed by the Solar Program personnel, 3) classes on the design, installation, and purchase of solar systems, 4) the establishment of a major solar document collection (with a special user-oriented reference table) in the City Library, 5) a solar building plan review service, and 6) an "at-your-request" on-site energy audits program. Regardless of the manner in which potential customers desire to obtain information (reading, listening, discussions, etc.), it will be easily accessible to them. In addition, to demonstrate the practicality of solar energy use in Palo Alto, the City will continue to install solar systems on

Solar Workshop Session

The ability of a municipal utility to work well with both its customers and with the business community will largely determine the success or failure of conservation and solar programs.



A Palo Alto Solar Demonstration Project

municipal buildings. (A third City system on a fire house will be installed this spring.) Consumers who are more concerned with solar product assurances than current general consumer information provides will find the fact sheet on local solar business services, and the *Design and Installation Standards* booklet useful.

The solar technologies receiving the most attention in the comprehensive public education service will be those that the citizens have indicated most interest in and that are widely available through the local solar industry. New innovations will be recognized through an awards program (Solar PAL).

Low Interest Financing. It is commonly recognized that the high initial cost of solar systems significantly constrains the solar marketplace. To expand the solar marketplace, the City of Palo Alto has initiated an 8 percent loan program which is now available to residents and owners of both single-family and multiple-family dwellings. Three types of systems are eligible for financing—solar domestic water heating, active swimming pool heating, and active solar space heating. During 1981, the City will consider expanding the financing effort to include passive solar technologies and commercial/industrial applications.

Under the current program, financing is available (until funds are depleted) for solar systems installed after January 1, 1981, and which meet the established design and installation standards. Consumers may select any licensed solar contractor to install their system or may install it themselves under this program. It is important to note that the design and installation standards were developed by the City in close association with the local solar industry.

Modification of City Utility Rules and Regulations. Most current Utility Rules and City Regulations were developed with little or no consideration of solar energy use in the community. The existing City Rules and Regulations are being reviewed for their relationship to the use of solar energy. Where conflicts are identified, modifications will be proposed. However, few problems are expected as discussions with citizens and the solar industry have indicated that Palo Alto is already amenable to solar energy use and that citizens and installers have few problems working with the City.

The City of Palo Alto has initiated an innovative program to encourage the use of solar energy in the community. This solar program reflects a sincere attempt to meet the needs of all citizens of the Municipal Utilities, and be responsive to the private sector. Persons interested in participating in this program are invited to contact the City. □

Affordable Housing Competition

The Government's Office of Appropriate Technology and the California Department of Housing and Community Development are sponsoring a statewide competition to stimulate and promote the availability of affordable housing in California. This is not a conventional design competition, but is instead a competition for new, workable ideas. Innovative approaches to financing, technology and materials, mass production, shelter design, energy-conserving applications, streamlined permitting procedures, and any other strategies that can help resolve the state's current housing dilemma are invited. The competition is open to residents of California, companies or corporations licensed in the state, local jurisdictions, and local or statewide organizations of any kind..

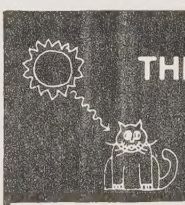
Schedule:

May 1, 1981: Closing for all entries.

June 1981: Winners announced at the Pacific Coast Builders Conference.

Contact:

Robert Boras, Director
California Affordable Housing Competition
Governor's Office of Appropriate Technology
1530 Tenth Street
Sacramento, California 95815



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SETTING YOUR SIGHTS ON THE SUN: A PALO ALTO GUIDE TO SOLAR ENERGY USE

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August, 1983

A well-designed solar energy system could be a wise investment for virtually all Palo Altans. Many solar options are available today. You may wonder what solar applications make sense for you. This booklet is designed to help you answer this question and obtain the best solar system for your dollar.

BETSY BECHTEL, MAYOR

SECTION I

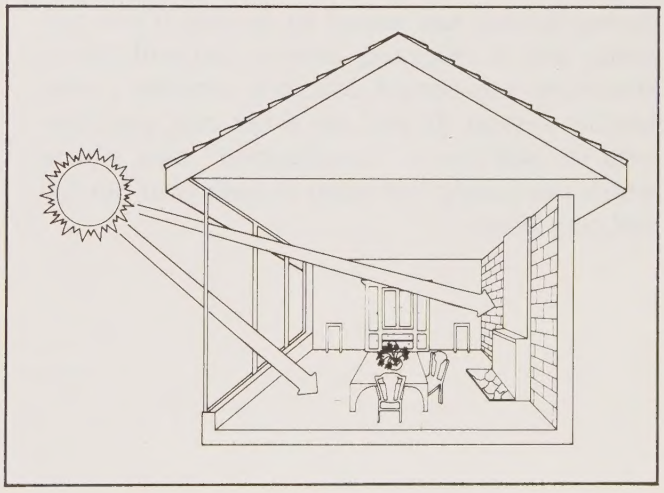
DETERMINING YOUR SOLAR OPTIONS– WHICH ARE RIGHT FOR YOU?

As the costs of gas and electricity continue to rise, many Palo Alto residents and business persons are turning to abundant, lower cost solar energy to meet their energy needs. There are many attractive options available for putting solar energy to work in your Palo Alto home. Solar energy systems can be used to provide lower cost heating for your home in the winter, cooling in the summer, year-round heating for your household water, as well as heating for a swimming pool or hot tub. One out of every twenty single-family homes in Palo Alto already uses solar energy. Chances are some form of solar energy could increase the comfort and the energy efficiency of your home as well. The sun is a clean, safe, and reliable energy source. Palo Alto's sunny climate makes its use here particularly attractive.

Your Palo Alto Utilities Department has examined all the potential uses of solar energy which make sense in our climate. The five most frequently used and cost-effective solar use possibilities are:

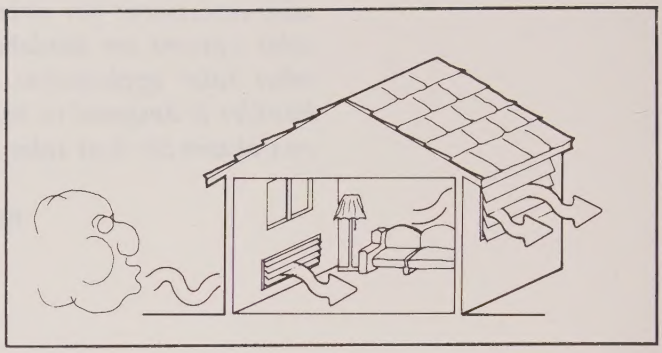
PASSIVE SPACE HEATING PAGES 4-7

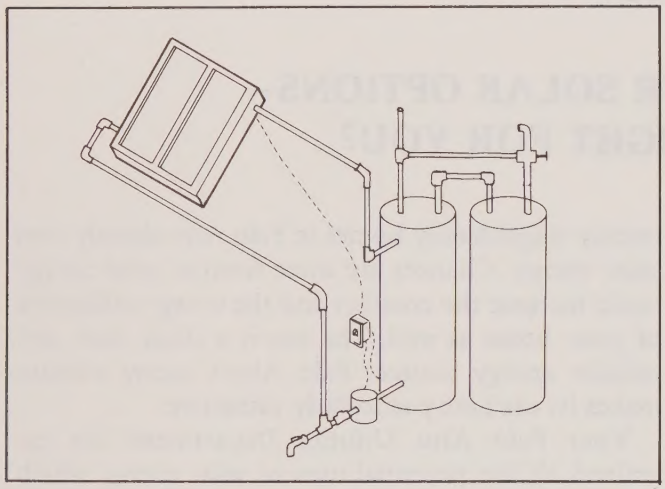
To heat a home, passive solar space heating is usually the least expensive way. Passive heating involves the use of windows or other passive solar energy devices (e.g., greenhouses, sunspaces, Trombe walls) to capture the sun's energy and directly heat your home. It is a particularly outstanding choice for any Palo Alto homeowner considering a room addition, remodeling, or building a new home. Forty to 60 percent of your home heating needs can usually be met quite easily, and 100 percent is a possibility in many homes with passive solar design.



PASSIVE SPACE COOLING PAGES 8-11

Passive cooling is an excellent method of increasing the summer comfort of your home while reducing or eliminating your need for air conditioning. Passive space cooling designs involve the use of shading devices to prevent unneeded summer sunlight from entering your home. Also available are passive cooling ventilation devices (such as "thermal chimneys") which can remove unwanted heat from living spaces on warm summer days.



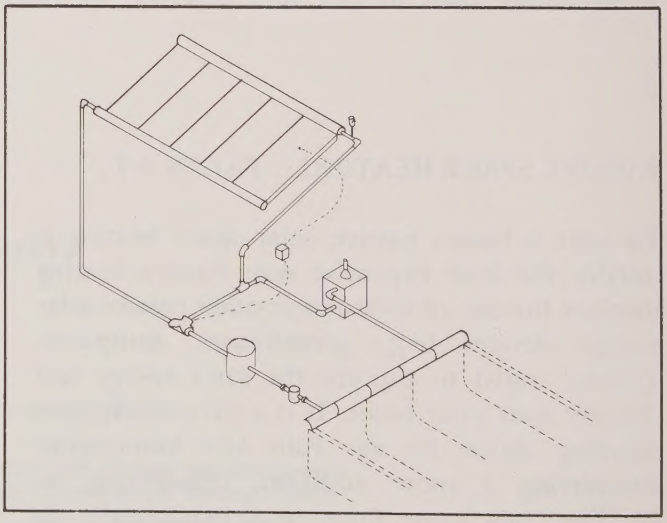


DOMESTIC WATER HEATING PAGES 12-16

Domestic water heating is now the most frequently used solar energy application in Palo Alto. Many homeowners have installed solar collectors on their roofs to provide 50 percent to 90 percent of their hot water. Solar collector panels can be installed in ways to be visually pleasing as well as efficient. There are many local contractors who can assist you, or you may wish to install your own. Assembling and installing your own solar water heating system may be an ideal weekend project if you are a "do-it-yourselfer."

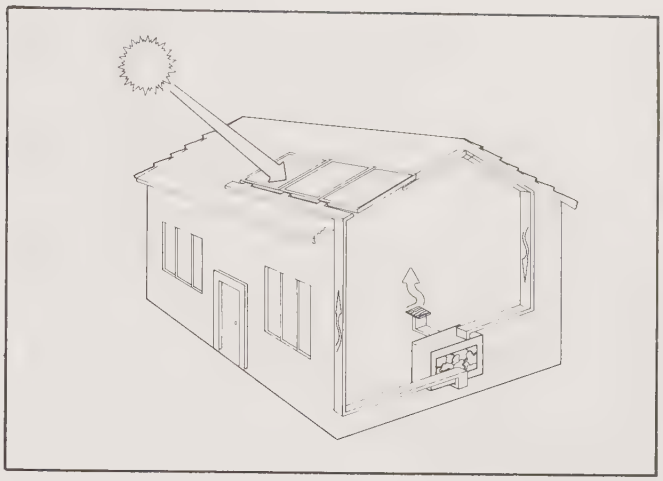
POOL AND HOT TUB HEATING PAGES 17-19

A solar system can be used to heat the water of your pool or hot tub. The water from the pool or hot tub can be pumped through solar collectors during the day and heated by the sun. If you currently heat a swimming pool or spa with gas or electricity, you should definitely consider a solar heating system. If you use a hot tub, you may wish to look into a "combination" solar system which can supply hot water to both your hot tub and your home.



ACTIVE SPACE HEATING PAGES 20-21

Active solar space heating systems are increasingly being installed by Palo Alto homeowners to one or more frequently used rooms with a "room heater" addition to a solar water-heating system. These designs can be particularly attractive for heating colder rooms on the north side of the home (where passive solar design applications are most limited). Larger active solar space heating systems, designed to heat the whole house, are quite expensive and will be a good investment for very few Palo Alto homeowners.



HOW TO USE THIS GUIDE BOOK

The benefits you can gain from any type of solar system will be determined by the particulars of your home, your lifestyle, and the quality of the system itself. Each chapter in Section I of this guide describes one of these five solar systems. The chapters can be read individually. You can begin with the solar option that attracts you most. Then we suggest that you look at the other chapters to see if there are additional solar options you may have.

After you have decided which system(s) show the most promise for your home, you can review the economic and technical considerations of these in depth in Section II. Alternatively, you may wish to attend one of the Utilities Department's Solar Buyers seminars. For more information on our evening seminars or on solar systems in general, please contact us, your Utilities Department's Solar Program at 329-2322.

This guide is not intended to provide a detailed explanation of how and why solar systems work. Palo Alto residents will find an extensive collection of solar reference books at the "Energy Information Center" in the Main Library. These books provide detailed descriptions on the design and installation of solar systems.

Chapter 1

PASSIVE SPACE HEATING

Passive solar design is generally the least expensive way to heat your home. With passive solar, the building itself is designed to collect, store, and distribute the sun's heat. Many existing homes can be "retrofitted" (adapted) with simple passive solar techniques to provide free heat to living areas. If you are planning to remodel a portion of your home, build an addition, or construct a new home, we recommend that you incorporate passive solar features into your design. Passive features (such as a sunspace, thermal wall, or additional southerly windows) should increase your construction cost no more than 1 percent to 3 percent—a nominal cost which can quickly be recovered through energy savings.

A passive solar system can provide anywhere from 10 percent to 100 percent of your space heating needs. Generally, the more extensive a system you design, the greater the capacity for heating will be. As a general rule of thumb, a reasonably sized passive room addition, sunspace, or increase in southerly facing glazing (glass) can provide 40 percent to 60 percent of the heat you need.

CAN YOU USE PASSIVE HEATING?

If adding a passive solar heating system to your home, you will need an unshaded area for the passive glazing (windows), Trombe (thermal storage) wall, or room addition. This unshaded area should be on the southerly side of your home (facing within 30° east or west of true south). The room(s) being heated may be on the south, east, or west sides of your home. You will want the solar heating during the winter months. During winter, the sun is on its lowest path across the sky. You should make sure there are no nearby homes, trees (remember some trees lose their leaves in winter and permit solar use), or other obstructions which would cast long winter shadows over the area you hope to use for passive solar heating. To assist you in evaluating your solar access conditions for the winter months, the City of Palo Alto has easy-to-use solar access devices which you can borrow. We will instruct you in their use. A detailed discussion of solar access and shading is contained in Chapter 7.

After you have identified an area with good solar access, examine existing windows in this area. Can any of them be enlarged? Will the unshaded area accommodate a new window, a greenhouse, or a solarium room addition? Alternatively, is there unshaded roof area facing south such that skylights or clerestory windows could be added to bring sunlight and heat into the house?

THE BASIC DESIGN FEATURES

The basic premise of passive solar heating is to collect the sun's energy using structural features of the house. The sun's energy can be collected directly in the living space where heating is desired, or indirectly at the house's outer walls and distributed to rooms as needed. The solar heat can be distributed through the house by natural thermal flows, or by small fans or blowers, and sometimes with duct work.

We recommend that you use double-paned glazing (windows with two layers of glass) and that all passive heated rooms be well insulated. These two measures are an integral part of good passive design in Palo Alto's mild climate. Passive systems incorporate a method of storing the heat gained during the day for use during cooler periods. This heat-storing material is generally referred to as "thermal mass." The mass materials absorb heat when the air is warm during the day, releasing it as it is needed when the rooms cool in the evening or on cloudy days. Typically, heat for one-and-one-half overcast days can be stored easily. Mass is important in Palo Alto's climate of warm days and cold nights.

Commonly used thermal mass materials are concrete, brick, adobe, and water. Each can be incorporated into the design of a new home, and some can be added to existing homes. A brick fireplace or a tile floor, if properly designed, can serve as thermal mass. Specially designed water storage containers are also available. Some serve a dual function as window seats.

COST

Passive solar heating systems vary greatly in price, depending on what you want to do and how much of your existing home must be altered to accommodate the system. Passive solar can be incorporated into remodeling or new construction with only a 1 percent to 3 percent increase in construction cost. Passive additions may range from $300 for a direct gain system to $1,000 to $2,000 or more for a large sunspace room addition.

An inexpensive passive technique to consider is reorienting an existing window to the south to increase direct passive gain. This can be done for as little as $100 and has been particularly well accomplished on Eichler-style homes. Installing a large new south-facing direct-gain window may cost between $300 and $600.

A prefabricated attached greenhouse can cost $3,000 to $10,000. A full Trombe wall (thermal storage wall) can cost $4,000 to $10,000. (However, smaller Trombe walls can also be installed.)

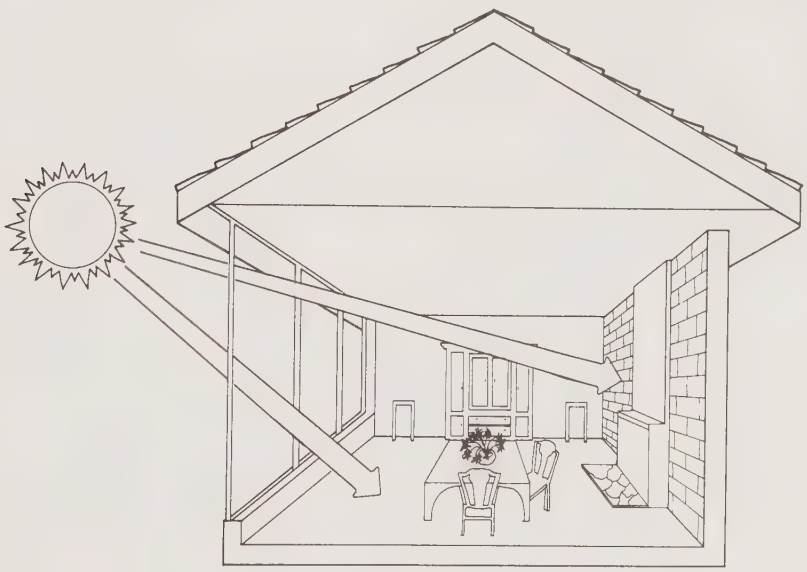
The State of California offers tax credits for most passive solar space heating systems. The state solar tax credit can also include costs incurred for conservation (i.e., insulation, weatherstripping, etc.) done in conjunction with the solar space heating. The federal government offers tax credits if the passive solar system's sole function is to provide heat and if it is not a structural component of the house.

YOUR SYSTEM DESIGN OPTIONS

The two major types of passive heating systems are described below. The most cost-effective passive solar technologies are usually direct gain systems (typically with a payback of 2 to 4 years) and sunspace additions (typically with a payback of 2 to 8 years). Similar energy savings may be obtained with either of the systems. You should select the passive system which best suits your design situation and lifestyle. For example, you would not install a heavy concrete Trombe wall in the second story of your home, but a direct gain solar system could work very well there. If you desire added living area, you may prefer a solarium room addition to a more simple direct gain system.

DIRECT GAIN PASSIVE HEATING SYSTEMS

The most common type of passive heating system is "direct gain." With this design, sunlight is allowed directly into the living space through southerly facing windows, glass doors, skylights, or special high windows called "clerestories." The light is converted to heat when it strikes interior walls or floors. You can increase the passive heat gain of your home by adding more southerly facing windows. Owners of some Palo Alto homes have relocated windows from the north side of their homes (where windows only lose heat) to the south wall (where windows can have a net heating benefit) at very little expense.



DIRECT GAIN HEATING

Direct gain systems can easily be incorporated into kitchen remodeling projects, as well as into the design of family room or office space additions. The September 1982 issue of *Better Homes and Gardens* features an article on "Bumpouts" that may give you creative ideas in these areas. The thermal mass is a very important part of any solar heating system. The thermal mass of a direct gain system should be located where it will receive direct sunlight. This is four times more effective than mass that is not directly in the sun's rays. We generally recommend four square feet of masonry that is at least two inches thick, or one-half to one cubic foot of water storage for each square foot of direct gain windows. The mass should be located so that it is exposed to the sun for maximum efficiency.

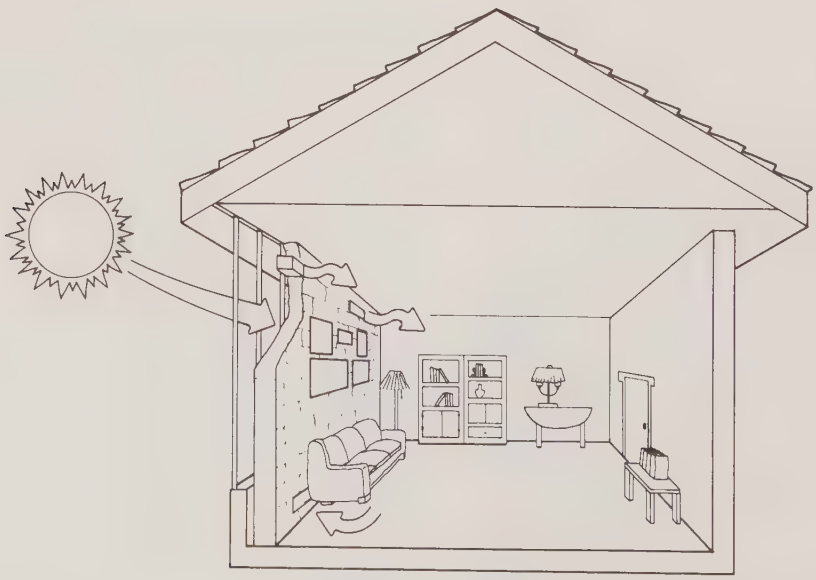
Advantages of a direct gain system are that it can be simple, reliable, and generally the least expensive solar option. The disadvantage in some applications is that sunlight will be coming directly into the house and may be more difficult to manage. To alleviate this problem, translucent venetian blinds can be installed to diffuse the incoming light.

INDIRECT GAIN PASSIVE HEATING SYSTEMS

In an "indirect gain" system, the sun's heat is collected in a thermal storage wall or a sunspace room on a southerly side of your home. The heat is transferred to the interior of the home as needed.

Thermal Storage Wall – The simplest form of a thermal storage wall is to use an existing exterior wall which is painted a dark color and covered with glazing on the outside. Glazing is a layer of glass or plastic that allows sunlight through. It should be approximately four inches away from the wall. Plastic glazing is lighter, often less expensive, and more versatile, but will probably have a shorter life than glass. This simple system is usually not highly efficient because the walls of most homes are not designed to store or transfer heat. Therefore, heat is mostly available only when the sun is shining, unless thermal mass is added to the home. Two types of more efficient indirect gain walls are the "Trombe wall" and the "water wall."

A "Trombe wall" (named after a French inventor, Felix Trombe) is a six- to ten-inch thick masonry wall with exterior glazing. The sun heats the wall behind the glazing, and the heat transfers slowly through the wall into the living area. Such a wall can store and provide many hours of useful heat. In addition, vents added to the top and bottom of the wall allow warm air to flow into the home when immediate daytime heating is desired. When the vents are open, cooler room air enters the wall at the bottom, rises between the wall and glazing as it heats, and returns to the room warmed, through the top vent into the living space. The vents are closed at night to prevent heat loss. A small Trombe wall, known as a Trombette wall, can be installed below standard windows.



INDIRECT GAIN—Trombe Wall

A "water wall" functions essentially the same as a "Trombe wall" except that a liquid is used instead of masonry. The water is stored in specially designed containers, drums, or columns. Few people install full sized water walls; most opt for smaller variations which have been adapted for easier use in existing homes. New, smaller designs are now available from several manufacturers.

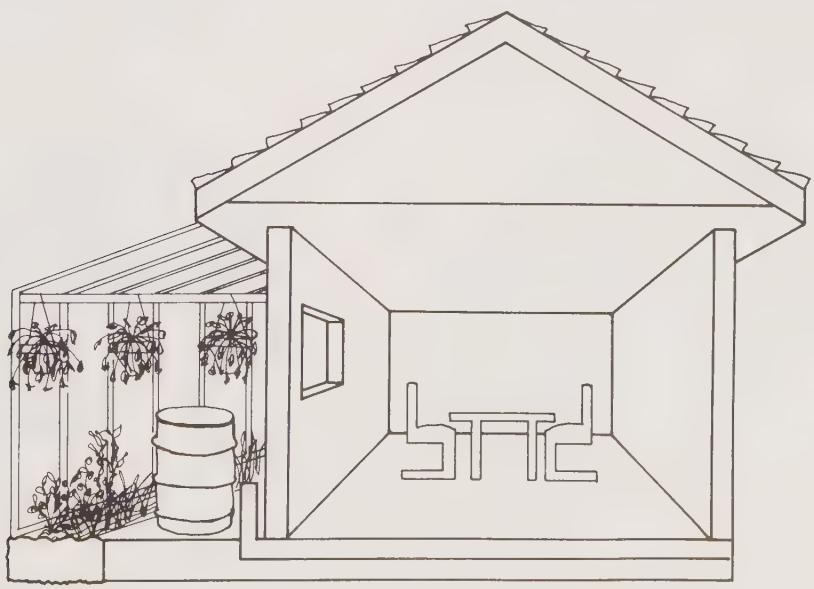
These include bookshelf and window seat units which can be incorporated more easily into the design of homes. There are also specifically manufactured "phase change" heat storage materials available for use in such containers. These materials store much more heat in an even smaller volume container, but they are very expensive.

Sunspace – The sunspace alternative may be very attractive to you as it adds useful floor area as well as heat to the home. A sunspace is a room addition that has extensive southerly glass to capture solar energy. Various designs are available and range from attached greenhouses, solariums, and garden rooms, to very conventional-appearing rooms.

The heat gained in the sunspace can be transferred to other areas of the home through ducts, or allowed to circulate freely from the sunspace to the house (a fan system may also be used). As with direct gain systems, shading devices should be incorporated into the design to prevent excess heat gain in summer. Operable vents near the top and bottom of the sunspace can be used to cool the room during summer. All passive heated rooms should have double-glazing and be insulated. We also recommend that southerly facing glass be vertical rather than sloped, in order to minimize unneeded summer heat gain.

A frequently used design rule-of-thumb which may aid you in estimating the size of your indirect passive solar system is that one square foot of southerly glazing will provide 50 percent of the heat required for eight square feet of living area. Thus, you would need at least 20 square feet of southerly windows to heat a 160 square-foot room. Thermal mass may be located either in the sunspace or elsewhere in the home.

A sunspace addition with direct access (such as through a hinged or sliding glass door) to your residence is considered habitable space and will be subject to all building code requirements for a living area. Therefore, you must consider electrical service and other conveniences in this case. If you add an attached greenhouse with no direct access to the residence (just windows and vents for heat flow), the building code requirements are far fewer. However, you cannot cover all bedroom windows with a greenhouse or other room addition. All bedrooms must have at least one window exiting directly to the outdoors for fire safety. (A Trombe wall can be modified to satisfy these requirements.)



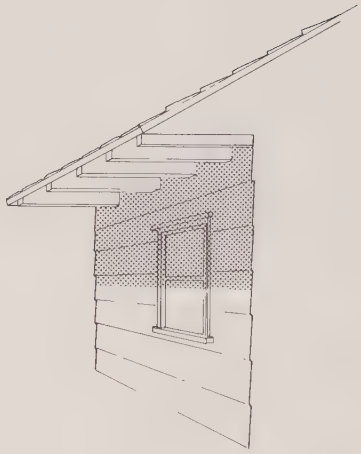
INDIRECT GAIN—Greenhouse

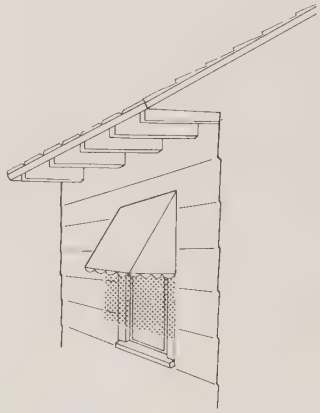
Chapter 2

PASSIVE SPACE COOLING

Summers in Palo Alto are generally very pleasant, but some days can be pretty hot. Few homeowners have installed air conditioners. In fact, many homeowners already use passive solar cooling devices instead. Just as a home can be designed for natural heating, it can also be designed for natural cooling. Passive solar cooling techniques prevent or remove unwanted heat from living spaces. If any rooms in your house get too warm during the summer, you should consider your passive cooling options to increase your summer comfort or reduce (or eliminate) the use of an air conditioner.

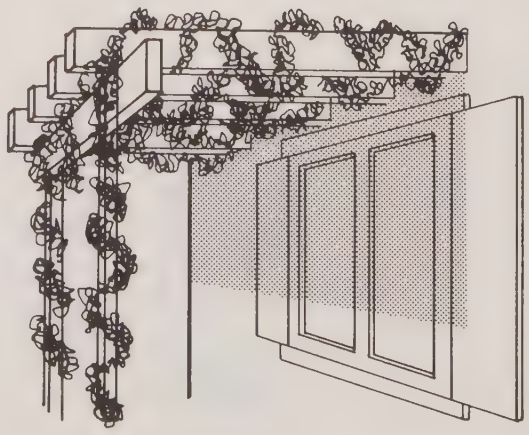
The most effective passive cooling technique is to keep the sun from entering the house during the summer. Exterior shading devices, such as roof overhangs, awnings, special window screens, and plants and trees work best to prevent sunlight from entering the home. Interior shades, insulating shutters, and louvers can also reduce heat gain, but are not nearly as effective as those which block the sun from hitting the outside of the glass. Ideally, your shading device should keep out the summer sun (which is high in the sky) but allow the lower winter sun into the house to provide heating.





EFFECTIVE SOLAR SHADING MEASURES

On the south side of the house, horizontal shades can be used to keep the summer sun off the windows. Such a shading device could be an existing roof eave, an extension of the roofline, or an arbor with deciduous vines covering it during the summer. An excellent (but out-of-print) Sunset book entitled *Summer Cooling* illustrates many of these options.

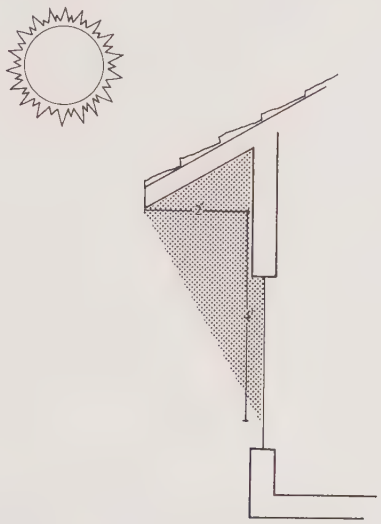


PASSIVE COOLING—Shading

HOW TO DESIGN AN OVERHANG

(Horizontal Shade)

An overhang should be designed to shade a window during the hottest part of the year, which is usually August. In August in Palo Alto, a southern overhang will cast a shadow of about twice its length. Thus, if you want a four-foot shadow, you would need a two-foot overhang.

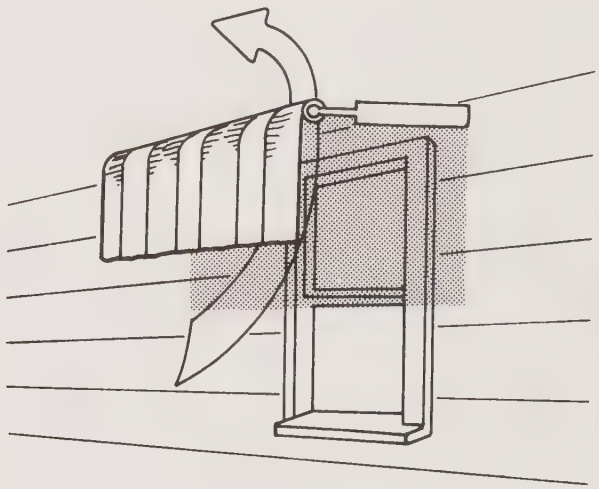


You can use this formula to size overhangs for your south-facing windows. Be sure not to make the overhang too large or you will prevent the sun from entering in the winter.

HOW TO USE SCREENS

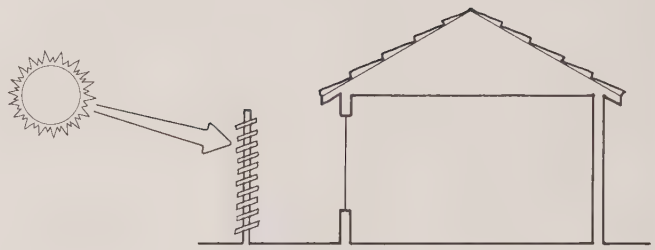
(Vertical Shade)

Exterior bamboo or canvas roll-down shades can be a very effective way of preventing the late afternoon sun from entering windows oriented toward the west.



Be sure to leave some space (one-to-two inches) between the top of the shade and the roof or window frame, to allow heated air to escape. Otherwise, trapped air will try to enter the house.

Late summer afternoons are usually the hottest part of the day in Palo Alto. Since the setting afternoon sun strikes low from the west, it is important to shade west-facing windows. If not already shaded by adjacent walls, these windows can be best protected by awnings, trellises, bamboo screens, or deciduous trees. Due to the low angle of the late afternoon sun, west-facing windows cannot be shaded by horizontal overhangs. Reflective glass in window frames or heat-reflecting window film applied to existing windows can reduce solar heat gain by as much as 75 percent. Remember though, reflective film on windows will also reduce useful passive heat gain during the winter. You should never place reflective film on windows where winter heat gain is important. Another potential disadvantage of films is their reflective appearance, which may detract from the aesthetics of your home or displease the neighbors.



Shading of West Windows

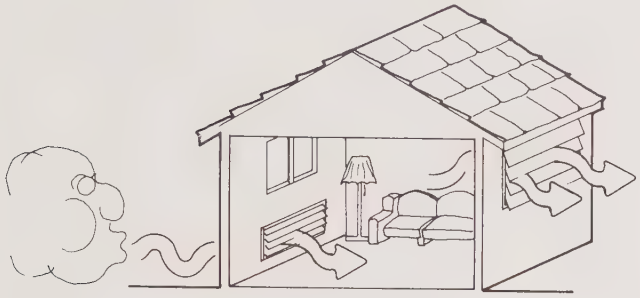
Many Palo Alto homeowners use deciduous trees for summer cooling. Deciduous trees lose their leaves in the fall and allow warming sunlight to enter the house in winter. In the summer the leaves provide a good source of window shading. Deciduous vines planted on a vertical or horizontal trellis can offer the same type of protection from the summer sun, while allowing the winter sun to come through. Be careful in your tree selection; make sure that any tree you choose is placed so that it will not grow to shade any roof-top solar collectors.

Shading with Deciduous Tree

METHODS TO ACHIEVE ADDITIONAL PASSIVE COOLING

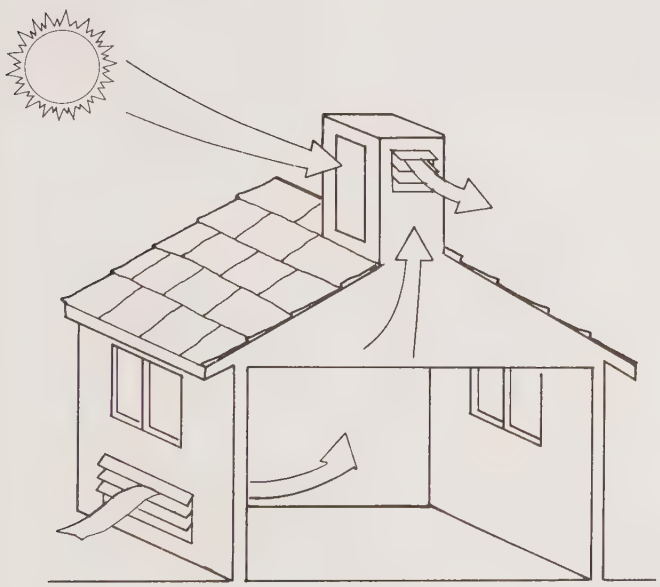
Although most Palo Alto residents find that passive shading alone provides all the summer comfort they desire, you may also wish to consider using two passive solar techniques to remove unwanted heat from the home after it has entered. The first method of keeping your home cool is to add "thermal mass," which will absorb and store heat during the day and exhaust it to the cool night air. The same thermal mass used for heat storage in the winter can also serve a summer cooling role if it is located within the shell of your home. Masonry (as in a fireplace, wall, interior stucco, or rock storage) or containers of water can be used as thermal mass. Nighttime ventilation with fans will speed up this cooling process, allowing the mass to cool down and be ready to offset more heat the next day. The second type of

cooling relies on natural thermal flows, taking advantage of the fact that hot air rises. Operable windows located at the highest and lowest spots of the house can be used to release hot air trapped near the ceiling, replacing it with cooler ground air. Preferably, cool air is drawn from a shady spot on the north side of the house or from the cool ground air of a basement.



PASSIVE COOLING—Ventilation

To improve this air flow, a "thermal chimney" can be added, extending from your room ceiling through your roof. A "thermal chimney" ventilation shaft usually has glazing on its southern side to permit the air at the top of the chimney to heat up. This super-hot air draws warm air from your home more quickly and replaces it with cool air drawn from the north side of the house. Of course, the simplest variation of this cooling option is to improve cross-ventilation by using or adding vents or operable windows on the sides of the house facing toward and away from the direction of the wind.



PASSIVE COOLING—Thermal Chimney

COSTS

The costs associated with passive cooling applications vary greatly, depending on the extent of modifications you make. Adding passive cooling to your existing home can range from a very small expense (installing bamboo shades or planting a deciduous tree), through slight cost (attaching awnings), to substantial cost (adding a thermal chimney). As with passive heating, passive cooling systems can be incorporated into remodeling plans or new construction at the design phase with little or no additional construction cost.

A state solar tax credit is available for many passive cooling installations. These include exterior shading devices, special ventilation devices (such as thermal chimneys or air intakes), and thermal mass. State and federal conservation tax credits may be available for other passive cooling methods, but only if you currently use an air conditioner and the passive cooling measures are recommended by a Residential Conservation Service (RCS) auditor.

Chapter 3

DOMESTIC WATER HEATING

Over 400 Palo Alto homeowners use solar energy to provide 50 percent to 90 percent of their hot water annually. If there are two or more people living in your house and you can take advantage of available income tax credits for solar systems, a solar water heating system may make sense for you, too. If there are four persons in your household, a solar water heating system is definitely a sound option to investigate. If you live alone or use very little hot water, a solar water heater is probably not the best investment for you.

When considering a solar hot water system, you need to determine if you have a suitable unshaded location for the collector area. The unshaded area required on a southerly facing roof (within 45° of south), wall, or yard for collection is approximately 10 to 20 square feet per occupant. Since you will want the system to operate year-round, the area should be free from winter shading (remember, deciduous trees lose their leaves in the fall). Palo Alto's Solar Program has solar access devices which you may borrow to determine the solar feasibility of collector locations. If you have any questions regarding solar access, you may wish to turn to Chapter 7 of this booklet.

With a solar system, you will always have adequate hot water. Typically, with a solar water heating system, your existing water heater receives solar heated water, stores it, and boosts it up to the appropriate temperature. Many Palo Alto homeowners with solar water heating systems find that they can turn off their natural gas or electric water heaters for five or six months of the year, relying completely on the sun for their hot water needs during this period.

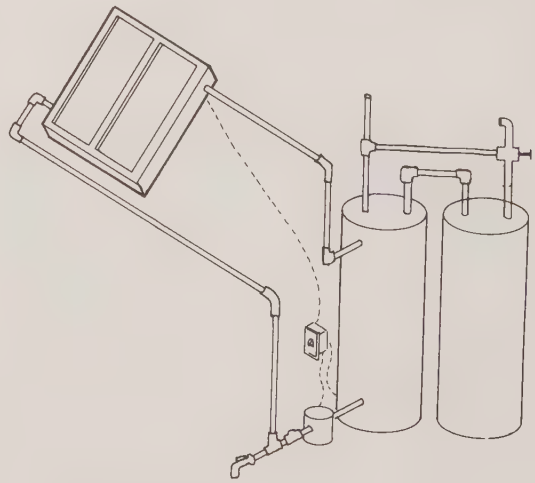
SYSTEM DESIGN OPTIONS

There are several types of domestic hot water systems, varying in price and efficiency. The most common type found in Palo Alto is the active flat-plate collector system. However, passive solar heating systems are becoming quite common also. You may wish to consider both of these solar options.

Active Water Heating Systems

Active Flat-Plate Collector System – This solar system utilizes flat-plate collector panels to absorb the sun's heat. The panels are usually made of copper, steel, or aluminum absorber plates with copper tubing. As liquid flows through the tubes, it captures the heat from the metal. The metal absorber plate is painted black to increase the absorption of the sun's heat. The surface of the panel exposed to the sun is covered with glazing (usually glass) to allow sunlight through, while preventing heat from escaping. Generally, a single layer of glazing is all that is necessary in Palo Alto's climate. The back and sides of the collector frame are well-insulated to prevent heat loss.

The system works by pumping a thermal fluid (water or anti-freeze) from the storage tank through the collectors, where it is heated, and back to the storage tank (if anti-freeze is used, a heat exchanger will separate your drinking water from the fluid). A controller linked to temperature sensors causes the pump to circulate the fluid when solar energy is available. As water is drawn from a tap in the house, preheated water from the solar storage tank moves into the existing back-up water heater where the temperature is boosted up, if necessary, to the delivery temperature.



ACTIVE FLAT-PLATE COLLECTOR SYSTEM

Since hot water is used year-round, the collectors should be oriented to capture the low winter sun as well as the higher angle of the summer sun. The ideal orientation for year-round performance is to have the collectors facing directly south. However, your collectors do not have to face due south. Very acceptable performance can be obtained if the collectors face within 45° east or west of due south.

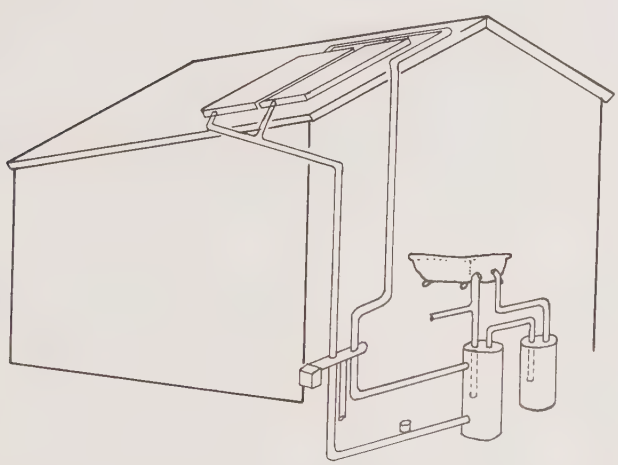
Collectors tilted up at about 35° to 40° from horizontal will give optimum year-round performance. However, collectors can be mounted at any angle from about 18° (the roof pitch of many Palo Alto homes) up to 50°, with only a 2 percent decrease in the annual performance of the system. This flexibility in collector tilt and orientation can allow you to install your solar panels without racks in a very aesthetically pleasing manner. The finest solar installations look like dark skylights on a roof.

You should locate the collectors and the new solar storage tank as close as possible to the existing water heater. This, together with insulating all pipes and storage tanks, will minimize energy losses from pipes. Typically, your solar storage tank should hold about 1.5 gallons of water for each square foot of collector area. Table 3-1 shows typical collector area and corresponding solar storage tank size based on household size.

Table 3-1

COLLECTOR AND STORAGE TANK SIZE

Household Size	Collector Area (Sq. Ft.)	Storage Tank Size (Gals.)
1	18–32	30–52
2	32–36	52–66
3	36–45	52–66
4	45–64	66–82
5	64–80	82–100



TYPICAL DOMESTIC WATER HEATING SYSTEM

Water expands as it freezes, and this can burst pipes and damage collectors. A solar system must include a method to insure against freezing. Even in Palo Alto's relatively mild climate, temperatures drop below the freezing point of collectors several times a year. (A solar collector can freeze even when the air temperature is as high as 42° F.) There are four active flat-plate collector freeze-protection techniques. Each technique has its advantages and disadvantages, and all work well when properly maintained. They are discussed in the box on page 14.

FREEZE PROTECTION FOR ACTIVE SOLAR WATER HEATING SYSTEMS

Recirculation — In a recirculation system, a temperature sensor in the collector is connected to the controller which operates the pump. When temperatures drop toward freezing, the controller turns the pump on, which sends warm water from the storage tank through the collectors. Once the collectors warm up, the pump is turned off. The process is repeated as often as necessary to keep the panel temperature above freezing.

An advantage of a recirculation system is that it is a simple, inexpensive means of preventing panel freezing. The system also contains few parts which could go bad. However, recirculation of heated water decreases the efficiency of the system because collected solar heat is lost to the night air, and electricity is used to circulate the water. Also, because this method relies on electricity, it will not operate during a power outage. If a simultaneous freeze and power failure occurred, the system would have no means of freeze protection. This freeze-protection system is common in Palo Alto.

Draindown — A draindown system has a special valve which automatically drains the water out of the collectors when sensors indicate freezing temperatures are approaching. Once the danger of freezing has passed, the valve closes and the panels automatically refill with water.

An advantage of the draindown system is that the valve is also triggered to open during a power failure, so the system is protected even if the electricity goes out. It is important that the collectors and plumbing be designed to slope correctly so all the water drains down from the system. The draindown valve should also be checked periodically to make sure that it is functioning properly. This freeze protection system is also common in Palo Alto.

Drainback — A drainback system is a "closed-loop" system with the heat transfer fluid contained in a separate plumbing line from the domestic water supply. During freezing conditions, the fluid drains from the collectors into a tank, emptying the collectors to avoid freeze damage. A drainback system drains the collectors whenever the pump is turned off (such as at night, during a cloudy portion of the day, or during a power failure). The water is then pumped back up into the collectors. The system loses some efficiency because it is a closed-loop design which requires a "heat exchanger" (copper tubing through which heat transfers from the collector fluid to the storage water). These systems are rarely used in Palo Alto.

Anti-freeze — This system is a closed-loop system using an anti-freeze solution or an oil as the heat-transfer fluid. This fluid will not freeze and can remain in the collectors during freezing temperatures. A relatively new variation of this freeze protection method is a system that uses freon. The freon changes to gas as it heats, and converts back to a fluid as it releases energy.

Anti-freeze systems are relatively inefficient because they use double-wall heat exchangers to ensure that your water cannot be contaminated by these toxic fluids. The pH (acidity) of anti-freeze solutions must be checked periodically, and the fluid must be replaced every two-to-four years to prevent corrosion. These systems are rarely used in Palo Alto.

Passive Water Heating Systems

There are two "passive" solar water heating system designs which you may wish to consider. These systems do not use pumps to move water from the collectors to your storage tanks and are generally less expensive than active water heating systems.

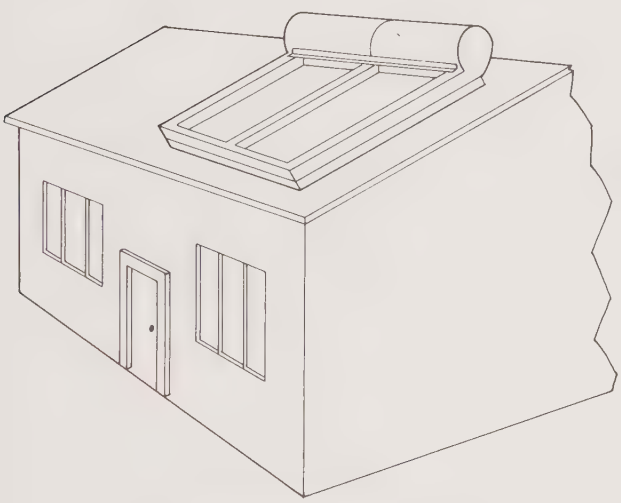
Thermosiphon

A flat-plate collector system does not necessarily have to use a pump to circulate the fluid. A "thermosiphon" system relies on the principle that hot water is less dense and, therefore, more buoyant than cold water. The solar storage tank is placed above the collectors to allow the heated fluid to rise into the tanks by natural convection. As the hot water from the collectors rises, cooler water from the bottom of the tank moves down to the collectors to replace the rising warm water. A thermosiphon system may not be quite as efficient as a pumped system because the water does not move through the collectors as quickly. These systems have fewer parts and almost no moving parts; therefore, they should require less maintenance than an active system. Freeze protection is generally provided by a heating element on or near the collector panels. Some systems incorporate a second freeze-protection element, a drip-valve, which will release a slow flow of water if freezing is a possibility.

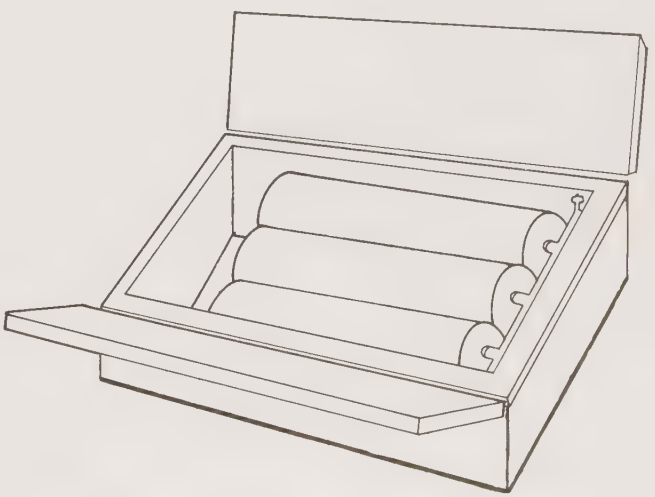
If you are installing a thermosiphon system, the location of the storage tank relative to the collectors is very important. Because the storage tank must be located above the collector, you may be more limited in choosing a location for this type of system. You could build it into an attractive storage or patio structure, or have the collectors on the roof and the storage tank in the attic, or mount the entire system on the roof. Keep in mind that an 80-gallon tank full of water will weigh about 800 pounds. Structural reinforcement is rarely necessary before roof mounting with a passive system; however, you should examine the structural stability of your roof before installing one of these systems.

Integrated Collector/Storage ("Breadbox")

In a "breadbox" or integrated system, the collector and storage tank are combined into one unit. The system consists of a black storage tank inside an insulated box with glazing on the side of the box facing southward. The sun's energy is absorbed by the black tank, heating the water.



THERMOSIPHON SYSTEM



INTEGRATED COLLECTOR/STORAGE SYSTEM

For a breadbox water heating system, you generally will need about 20 square feet of collector area per person, and 20 gallons of storage per person. The breadbox heater serves to preheat water that will flow through the backup heater before being used.

The large amount of water in a breadbox system makes it unlikely to freeze in Palo Alto's climate; however, nighttime heat losses can be high. We recommend that you also consider double-glazing the unit and adding an insulating cover which can close over the glazing at night. All connecting pipes should be well-insulated. A breadbox system constructed without an insulating cover works best for a household that uses hot water primarily in the late afternoon or evening.

SYSTEM COST

A solar water heater for your house will vary in price from one contractor to another due to the system's component materials, special features, and the contractor's pricing. If you do the installation yourself, you can cut costs by approximately one-half. In addition, low-interest financing is available to eliminate any initial cost and to spread the system cost over a period of up to ten years.

The table below will give you an idea of the approximate costs of both contractor-installed and do-it-yourself (D-I-Y) active solar water heating systems. Generally, 10-to-20 square feet of collector area is installed for each person in your household. Collector area and price will vary depending on the type of collector you select. High efficiency, "black chrome" collectors may be more expensive yet require a smaller area. Available state and federal tax credits can reduce the cost of a solar water heating system substantially. Tax credits have *not* been subtracted from the cost figures below.

Table 3-2

APPROXIMATE INSTALLATION COSTS

	Approximate Cost	
Collector Area (Sq. Ft.)	Contractor Installed	Do-it-Yourself
32	$2,700	$1,620
40	$2,900	$2,030
64	$3,500	$2,450
80	$3,900	$2,730

An integral collector system (or breadbox) water heating system may be more cost-effective than a flat-plate system if you use little hot water or are particularly handy around the house. A do-it-yourself solar system will cost only about $600 to $1,200 for materials. A contractor-installed breadbox system will cost $1,500 to $3,000.

To facilitate the installation of solar systems in Palo Alto, the City offers long-term, low-interest financing with no downpayment required. For further information contact us at 329-2322. Both contractor and do-it-yourself systems can be financed.

Chapter 4

POOL AND HOT TUB HEATING

If you heat your swimming pool or would like to extend your swimming season and raise your pool temperature, you should seriously consider a solar swimming pool heating system. If you are contemplating building a new pool, heating with gas should be considered only if you have no solar energy potential. This solar technology is already well accepted. Over 50 percent of Palo Alto residents who heat their pools today use solar energy. As gas rates continue to rise, more pool owners will be turning to solar energy.

For Palo Alto's climate, we generally recommend a solar collector area equal to at least 60 percent of your pool surface area. The collectors are typically located on the southerly facing (up to 45° east and 90° west of south) roof. If the system is to be used mainly during the spring to fall swim season, when the sun is high in the sky, the collectors can be mounted directly on the roof nearly horizontally or with little tilt and still be very effective. If you use the pool year-round, the collectors should be tilted up about 35° to capture the lower winter sun.

CAN YOU USE A SOLAR SYSTEM FOR YOUR POOL?

You can evaluate your home for the potential use of a solar pool system. Do you have an unshaded area on the southerly area of your roof large enough for the collectors? Ideally, the collector area should be unshaded from 9 a.m. to 3 p.m. during the months of May through October, and should be facing south. However, an area unshaded from 10 a.m. to 2 p.m. and up to 60° off of south will still allow for an effective solar swimming pool system. You can assess your solar potential with a solar access device (the City's Solar Program has one you can borrow) or by one of the other methods discussed in the "Solar Access" chapter.

Key Factors to Consider

The length of your swimming season, the temperature at which you keep your pool water, and solar access are the factors which will help you determine if solar energy makes sense for your pool. Each of these is discussed below:

Table 4-1
HEATING FOR SWIMMING POOLS

Swim Season	Pool Temperature	Generally Recommended Heating Source
June – August (3 mos.)	78°	Pool cover only (if pool is fully exposed to sun during the day)
May – October (6 mos.)	78° – 84°	Solar pool system with pool cover
Year-round or for therapeutic purposes	Varies	Solar pool system and cover with gas system as backup

If your pool surface gets adequate sunshine during the day, a pool cover may be all you need to provide a comfortable swimming temperature from June through August. Placed on the surface of your pool when no one is swimming, a pool cover insulates the water. A pool cover is the only method of conserving your pool's heat. The pool cover should be translucent to make use of solar heat gain during the day.

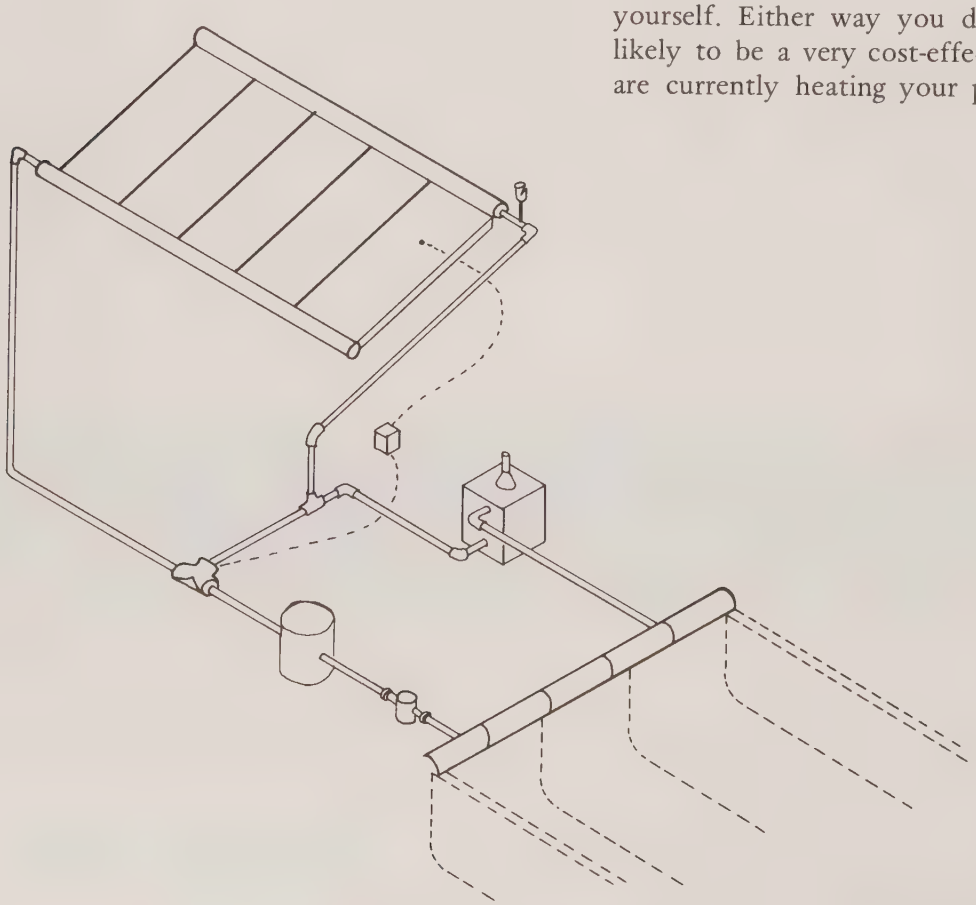
An active solar pool heating system can typically provide comfortable swimming temperatures for a six-month swimming season (May through October). A pool cover should be used to maintain temperatures in the spring and fall. Depending on system size and cover use, typical temperatures are 78° and higher. Many people do not use a cover during the summer because the pool may become too warm. Unless you desire a year-round swim season or higher pool temperatures (e.g., therapeutic use), you should have no need for a backup gas pool heater.

Since pool water does not have to be heated to very high temperatures, unglazed plastic or metal collectors are typically used. Metal collectors are somewhat more expensive than plastic collectors but do have a longer life expectancy. Solar panels with glazing may be worth the extra cost only if you swim year-round or if your collectors are located in a very windy location.

Other than collector panels, few components are needed for a solar pool heating system. The existing pool filter pump is usually used to circulate water through the collectors, and the pool itself serves as the storage "tank." A control valve with a sensor operates the system when adequate solar energy is available and turns off the system at night and on very cloudy days.

Cost

A solar swimming pool heating system will typically cost $3,000 to $5,000 if you have a contractor install it, or about $2,000 to $3,500 if you install it yourself. Either way you do it, a solar system is likely to be a very cost-effective investment if you are currently heating your pool with gas. Today's



SOLAR POOL HEATING SYSTEM

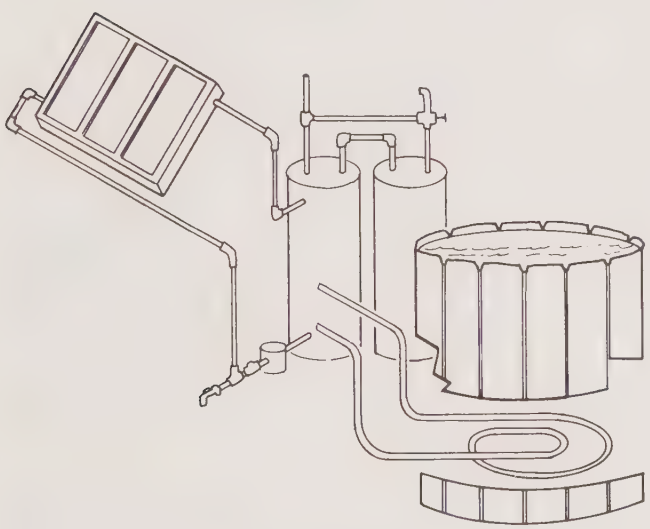
gas prices are structured so that the more gas you use, the higher the rate you pay. A heated pool usually consumes the higher-priced gas; therefore, each therm of gas you save will be saved at the higher rate. Those pool owners still heating with gas may already be paying $3 to $5 for each hour their pool heater operates.

The state and federal governments do *not* offer tax credits for installing a solar pool heating system. However, a pool cover may be eligible for the state conservation tax credit.

HOT TUBS (AND SPAS)

Solar energy can also provide a substantial portion of your hot tub heating needs. A solar hot tub system differs from a solar pool system because a hot tub is more commonly used year-round and is operated at a higher temperature. Therefore, glazed collector panels capable of providing higher temperatures must be used. The solar system usually functions to keep the water at about 100° F, and a back-up heater is turned on to boost the water temperature when you anticipate using the hot tub. To retain these temperatures, a good quality insulating cover should be kept on the hot tub when not in use.

A hot tub solar system can be designed to incorporate heating for domestic water as well. One or two additional glazed panels are added to the collector array. In such a system, the hot tub water must be isolated from the home's domestic water. Usually the domestic water is circulated through the collectors and then through pipes in the hot tub. Heat transfers from the domestic water to the tub water when the tub is to be heated.



SOLAR HOT TUB HEATING

Solar Access

A solar hot tub heating system generally involves two collectors (about 64 square feet of collector area). The collectors are usually mounted on the roof (though they could be placed elsewhere) and drain back into the tub when the pump is turned off.

You should look for an appropriate collector location on your roof or in your yard that will allow the collectors to face within 45° of south. The area should be unshaded year-round if you use your hot tub all year. Hot tub collectors are usually tilted up between 30° to 50° to capture both the high summer sun and the low winter sun. You can evaluate the solar access potential of a site using one of the methods discussed in Chapter 7. The site should be evaluated to see if it will receive adequate sunshine on the 21st of December, which is the day when the sun is lowest in the sky.

Cost

You can expect to pay about $3,500 for a contractor-installed hot tub system or $2,000 for materials if you install it yourself. The insulating cover may be eligible for the state conservation tax credit. If you install a combined system (hot tub and domestic hot water), you must specify for tax purposes what portion of the components serve each function.

Chapter 5

ACTIVE SPACE HEATING

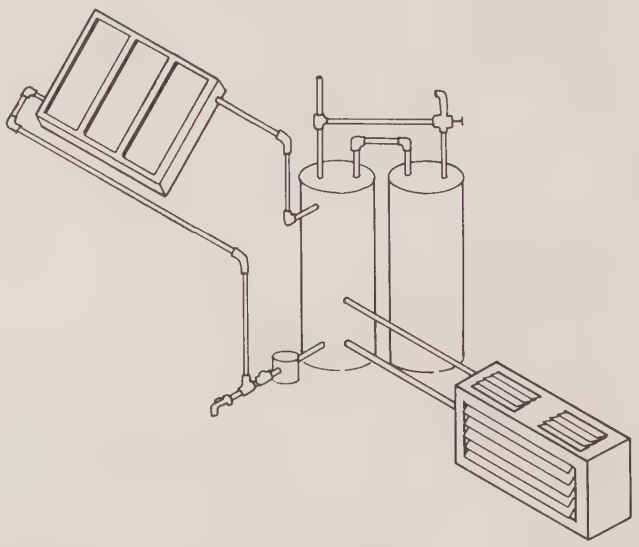
There are a few whole house active solar space heating systems in Palo Alto. Such whole house systems can be quite expensive and are cost-effective for only a few Palo Alto homeowners. However, if you have one or two particular rooms you frequently use, you could consider the increasingly common "combined" solar system design. A "combined" system adds one or more room heaters and a solar panel (or two) to a standard solar domestic water heating system. These systems can be particularly useful in heating cold north rooms beyond the reach of your passive design options.

An active solar space heating system usually requires a southerly facing (plus or minus 30° of south) collector area of 1/6 to 1/4 of the area of the rooms to be heated. Usually the panels are placed on the roof, but an unshaded yard or wall area may be suitable. Remember that the 21st of December is when the sun is lowest and shading problems are worst. This is also a time when you will desire the most space heating. The City of Palo Alto's Solar Program has an easy-to-use device you may borrow to determine your solar access situation. If you believe you may have a solar access problem, Chapter 7 of this booklet may also assist you in evaluating this situation.

Since space heating is desired in the winter, collectors should be oriented and tilted to capture the low winter sun. The ideal is to have the collectors face directly south and tilted up about 50° from horizontal. Good system performance can be achieved with collectors oriented as much as 30° east or west of true south and with collectors tilted less steeply. For a system where the collectors will be used during the summer as well (e.g., a combined space and water heating system), they should be tilted between 35° and 50° up from horizontal.

Since space heating is a seasonal need, solar space heating collectors are used only during the winter in Palo Alto. Designing a system to serve more than one function allows you to take advantage of collectors that would otherwise lie idle during the summer. We recommend that you consider a "combined" system—one that provides space heating *and* domestic water or hot tub heating. A heat exchanger could run through the storage tank to preheat water entering the water heater, hot tub, or swimming pool. Such a system could save you more energy than a space heating system alone, making the overall investment look more attractive.

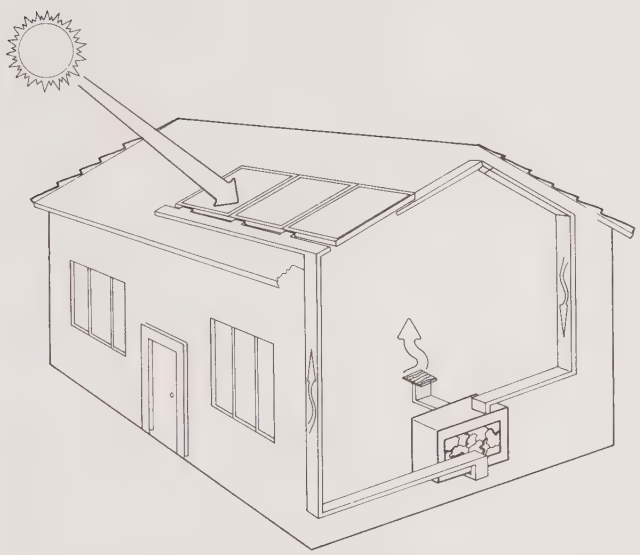
A "combined" system which is often cost-effective is a combined space/water heating system designed to heat one or more rooms. This is useful if you have a number of rooms in which you spend considerable time during the evening or day (such as a family room). This combined system is essentially a domestic hot water system to which another panel is added to provide extra heat. Hot water from the solar storage tank is circulated through a room heater (similar to a car radiator), and a small fan blows the heat into the room.



COMBINED WATER HEATING/ROOM HEATING SYSTEM

Both one room and whole house active solar space heating systems are usually sized to provide 50 percent to 70 percent of space heating needs. (A larger system is not usually cost-effective.) To supply the rest of the needed heat, an auxiliary heater is used. Usually, the existing heater is used as backup, and the solar system is hooked up to that heater's distribution and control systems.

Air Systems – Another option is an "air system," an active system that uses air warmed in specially designed panels or received from a passive solar air collector. These systems typically store the gathered solar heat in a large bin of rocks. During the day, air is circulated from the collectors through the rock-bed, gradually heating up the rocks. The rocks are typically one to two inches in diameter—large enough to allow for air circulation, but small enough to be heated all the way through. At night, household air is warmed by blowing it through the heated rocks.



WHOLE HOUSE ACTIVE SPACE HEATING SYSTEM

An active air system is suitable for connection with a conventional forced air heating system. We generally recommend one-half to one cubic foot of rock storage for every square foot of collector. A rock bin can be put in a basement, beneath a stair well, or in an outdoor shed. If you are building a new house or room addition, rock storage can be incorporated into the room design or put beneath the foundation.

An advantage of an air system is that there is no concern about freezing or corrosion. Disadvantages of the system are the space requirements for air ducts to carry heated air from collectors to storage and for the storage bin itself. Large air ducts are difficult to add to an existing home, but can be included as part of a new home design.

An alternative storage option for heat collected by an active air system is eutectic salt storage. Eutectic salts are capable of absorbing large quantities of heat per pound of salt. This allows the storage bin to be quite small. Eutectic salts are relatively expensive and require a more elaborate storage bin design, so they are not frequently used for residential systems.

Cost

"Combined" systems for one-room heating typically add $500 to $1,000 to the cost of a domestic water heating system. Whole house active solar space heating is generally quite expensive, ranging from approximately $16,000 to $18,000. Price will vary greatly depending on how much of your home you plan on heating. Both the state and federal tax credits are available.

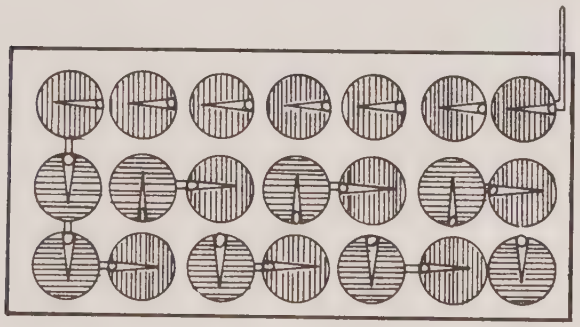
Chapter 6

WHAT OTHER OPTIONS MIGHT THE FUTURE HOLD FOR YOU?

There are several solar technologies which show promise to be viable for use in Palo Alto within the next ten years. Some of them have potential value for residential use while others may be more appropriate for commercial applications. Most are still in the research and development stage. In any case, these alternative solar techniques show promise of providing us additional power sources from the sun. Chances are in a few years you will be considering these additional solar opportunities to provide energy for your home.

Photovoltaics

The direct conversion of solar energy to electricity could greatly broaden the applications of solar. "Photovoltaic cells" are thin silicon or cadmium chips, usually about two inches square. When these chips are exposed to sunlight, an electron flow is triggered and an electrical current is produced. These chips are combined into a panel array for use.



PHOTOVOLTAIC CELLS

Photovoltaic cells are currently quite expensive (relative to other electricity sources) and so are used almost exclusively in remote locations where electrical system hookup is difficult, but as the manufacturing process is simplified and production efficiency improved, the cost of photovoltaics is becoming more competitive. Perhaps some day soon you will be able to generate power for your lights and appliances, or recharge your electric car, by plugging into the array of photovoltaic cells on your garage roof.

Wind Energy

Windmills have been used for many years to pump water and grind grain. Today, wind turbines generate electricity. Wind power is considered a form of solar energy because wind is caused by temperature differentials on the earth due to the sun's heat. Wind rotates a windmill or propeller that, in turn, circulates a generator to create electricity. This conversion process is highly efficient and can operate at night and on cloudy days. As windmill designs become more efficient and quieter, we may begin to see more residential uses of the technology (though rear yard space limitations will likely restrict their use in most Palo Alto residential areas).

Daylighting Devices

The sun is often utilized to provide natural daylighting for homes and offices. Recent variations in daylighting technology allow for broader use of the sun's light. Advances in this field include reflection devices that can bounce light deep into an enclosed space and reduce the need for artificial lighting. Present tests of these devices look promising. The new office building for the Tennessee Valley Authority is able to achieve useful daylighting 50 feet into office spaces using a solar daylighting design.

Absorption Cooling

Solar-powered absorption cooling uses a process similar to that of a refrigerator to extract heat from house (or business) air. The process requires high-performance collector panels capable of producing high liquid temperatures. The process for residential use is still in the experimental stages, and system cost is quite high. However, a number of American and Japanese firms are developing these systems.

SECTION II

CARRYING OUT YOUR SOLAR CHOICES

Now that you are familiar with your various solar opportunities and have selected one or more possibilities for your home, you will wish to examine these more fully. You will probably have many considerations: How many windows would you like in your solar addition? Who is a good designer? How to find the best contractor? Is that active space heating system really the right move for you? Can this be a do-it-yourself project? How can 100 percent low-interest financing be arranged? Perhaps the easiest way to answer these questions is to attend an evening solar buyer's seminar sponsored by the City. At these seminars, you can learn the latest on these and other questions, arrange for an informal plan review or feasibility analysis by our solar engineer, review contractor bids and quality standards, and ask any other specific questions you may have. Contact us at 329-2322 for information on the next seminar in your area.

Alternatively, you may wish to consult contractors directly, do further reading at the Energy Information Center (located in the Main Library), individually consult the City's Solar Program office, or independently research the topic further. The following section is provided primarily for those who wish to pursue independent research. Using this section, you can examine in depth the economic and technical considerations of your solar options.

The following chapters contain detailed procedures for calculating your energy consumption, solar economics, solar access situations, and do-it-yourself capabilities. You can briefly review these chapters for a general idea of the considerations, or you can delve into them deeply to produce a complete personalized evaluation of your options. If, at any point, you would like assistance in determining whether solar makes sense for you, feel free to call us at the Palo Alto Utilities Solar Program, 329-2322.

Chapter 7

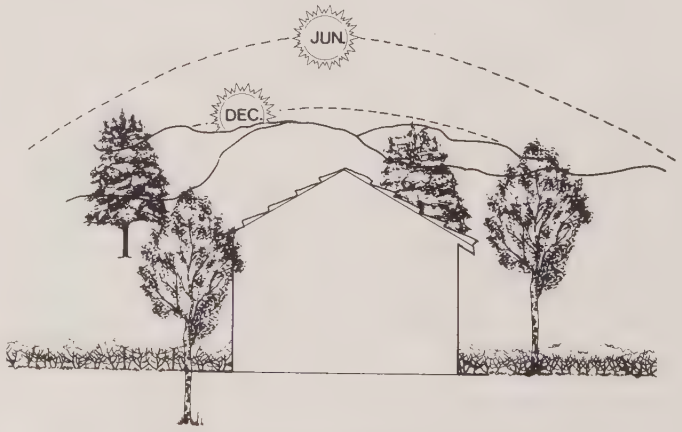
HOW TO EVALUATE YOUR OWN SOLAR ACCESS SITUATION

Most homes in Palo Alto have good solar access. Whether or not solar energy is appropriate for your home can, in large part, depend on your "solar access" situation. Solar access refers to the availability of sunlight necessary for the operation of a solar energy system. The solar collectors must be located to get plenty of direct sunlight during that part of the year in which you will rely on them. Trees, buildings, or other obstructions to the south may cause shading on a desired collector site. (Remember, some trees permit winter solar access after the leaves have fallen off.) You can have your contractor perform a solar access evaluation, or you can perform your own. Performing your own evaluation is quite easy if you follow the steps described below:

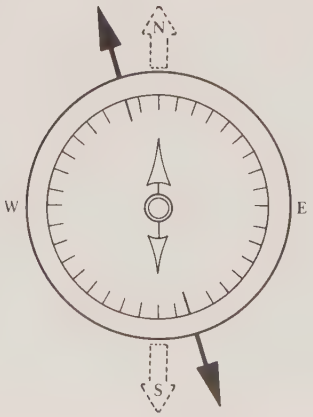
1. Identify your own solar access needs.
2. Consider your collector location alternatives.
3. Determine your current solar access opportunities.
4. Review potential future conflicts.

STEP 1: IDENTIFY YOUR SOLAR ACCESS NEEDS

The sun travels across Palo Alto's southern sky; therefore, you will need a southerly exposed area for direct collection of the sun's energy. At noon, during the summer, Palo Alto's sun is almost directly overhead (76°), giving most houses plenty of sunshine. However, at its lowest point on December 21, the sun is much lower in the sky, reaching an altitude of only 30° at noon and 23° at 10 a.m. and 2 p.m. Thus, the greatest potential for shading problems may be during the winter. The following chart can help you to identify your solar access needs and to determine whether this low winter sun will be important to your collection of solar energy. Your location should get sun during the key solar access months, depending on the system's use season.



SUMMER AND WINTER SUN PATHS



WHERE IS "SOUTH"?

For purposes of a solar system, "south" refers to "solar south" (or "true south") which is the direction toward the sun at noon Pacific Standard Time (or 1:00 Daylight Savings Time). You can find solar south by determining the direction of the sun at the appropriate time. You can also use a compass; "solar south" is 17° east of "magnetic south." (So, if you face the direction of a compass' southern arrow, solar south is 17° to your left.)

Table 7-1				
SOLAR ACCESS NEEDS				
Application	Use Season	Key Solar Access Months	Access Area Where Needed	Orientation Range
Passive space heating	Winter	Dec.	Southerly wall of home	South ± 30°
Passive space cooling	Summer	N/A	N/A	Southern and western windows
Domestic hot water	Year-round	Dec.	Southerly roof top or yard area	South ± 45°
Pool	Summer	Sept./ Oct.	Southerly roof top or yard area	South ± 60°
Hot tub	Year-round	Dec.	Southerly roof top or yard area	South ± 45°
Active space heating	Winter	Dec.	Southerly roof top or yard area	South ± 30°

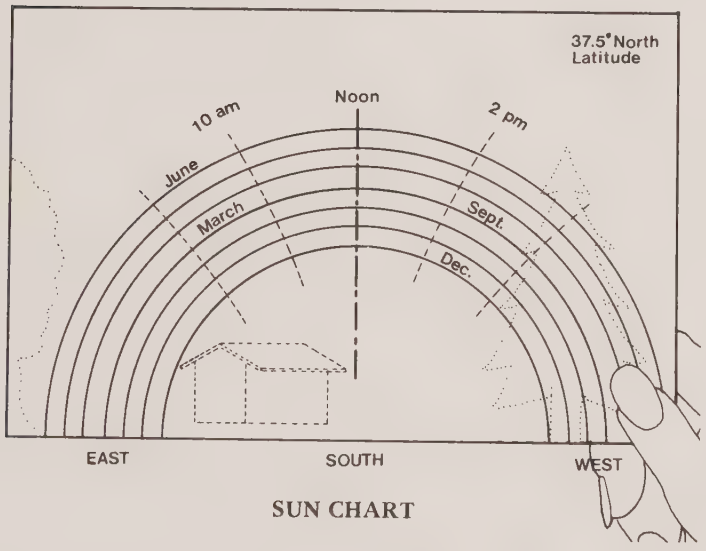
STEP 2: CONSIDER YOUR COLLECTOR LOCATION ALTERNATIVES

The roof of a house is commonly the sunniest location with fewest obstructions. However, your collection area also may be located in your yard or on a wall. If you are considering passive space heating, you will need solar access for the southerly facing wall area that you intend to use for solar energy collection. Solar collectors should be oriented (face) as close to solar south as practical. Since most Palo Alto homes run in a northwest-southeast direction, you may not have a part of the roof or walls that face due south. Although south-facing collectors achieve the optimum performance, an orientation considerably off south is acceptable. The amount you can deviate from south varies with each type of solar system, as shown in Table 7-1. If you do not have solar access directly to the south, you should try a different location or turn slightly east or west and examine your solar access potential. Because of our frequent overcast mornings, southwest would be preferable to southeast.

Where two or more good collector locations exist, select the spot which is closest to your heating storage area and backup heater. You will be able to minimize your piping or ducting expenses and heat losses through the pipes. Keep in mind while evaluating your solar access that many Palo Alto trees are deciduous, shedding their leaves in the fall. Thus, a deciduous tree, which shades during the summer, may allow sunlight to pass through in the winter. The windows that your home uses as a passive heating system can be shaded by a tree during the summer as long as that tree loses its leaves in the fall so that the sun will be available for winter heating.

STEP 3: DETERMINE YOUR CURRENT SOLAR ACCESS OPPORTUNITIES

If you want a simple way of determining the availability of sunlight, use a "sun chart." The chart plots the sun's path across the sky for different times of the day and year. The City of Palo Alto Utilities Solar Program has solar site selectors and sun charts which you can borrow to evaluate the solar potential of your home. Solar program staff can instruct you in the selector's use. With this chart mounted on a viewing stand with a level and compass, a homeowner can view the skyline from a proposed collector area to see if any neighboring obstructions will cast shadows there. The device indicates the hours of the day during various months that the spot will be shaded. You should have a "solar access fraction" (percentage of time when the area is unshaded) of at least 70 percent of the time between 10 a.m. and 2 p.m. during the months you plan to use your solar system. If you evaluate one location that does not have good solar access, chances are another location along the side or roof of your house will.



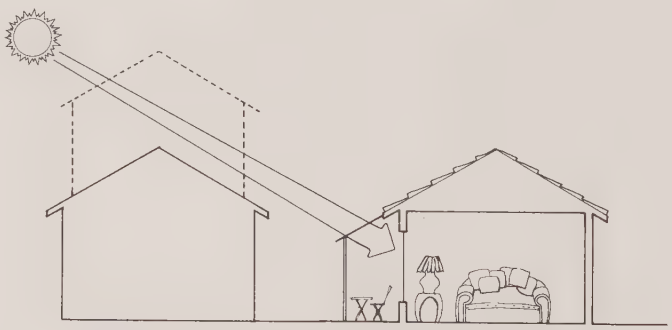
SUN CHART

STEP 4: REVIEW POTENTIAL FUTURE CONFLICTS

Once you have identified a location which has good solar access, examine it for potential future solar access problems. Remember, an active solar system can last for 20 to 30 years (or more if well-maintained), and a passive home addition can provide solar heating for as long as your house stands. Consider the various potential sources of future shading on your collector area, such as new construction or growing trees.

New Construction

What type of construction is possible on property to the *south* of yours? Your residential lot may be next door to another single-family lot, commercial lot, or multi-family lot. You should check with the City of Palo Alto's Planning Department (329-2496) to find out about the zoning of your property and the adjacent southerly properties. The type of facility there now may or may not be the largest structure which is permitted by zoning.



POSSIBLE SHADING—New Construction

For each type of property, the City of Palo Alto's Zoning Ordinance has established a "daylight plane." The daylight plane defines a three-dimensional "envelope" within which building is allowed on a lot. The envelope incorporates setback requirements and maximum allowable construction heights.

The table below shows this same information for the most common types of zoning. If you know how your neighbors to the south of you are zoned, you can easily define the areas on your house where solar access is protected by the zoning laws. Depending on how far from their property line you plan to install your solar system, you can protect it from being shaded by future buildings. Table 7-2 shows this information for the most common type of residential zoning—R-1. (Eighty percent of the residential lots in Palo Alto are zoned R-1.)

Table 7-2					
R-1 ZONE NEIGHBORS					
Collector's distance from property line	5 ft.	10 ft.	15 ft.	20 ft.	25 ft.
Minimum height of bottom edge of collector	21.5 ft.	20 ft.	18 ft.	16 ft.	14.5 ft.

If the property to the south of you is zoned other than R-1, the envelope in which your neighbors can build is affected by the width of their property. Therefore, the minimum height to place your collector to protect it from shading is determined by the width of your southern neighbor's lot. Table 7-3 below shows a protected collector height based on the distance from the property line for various width lots.

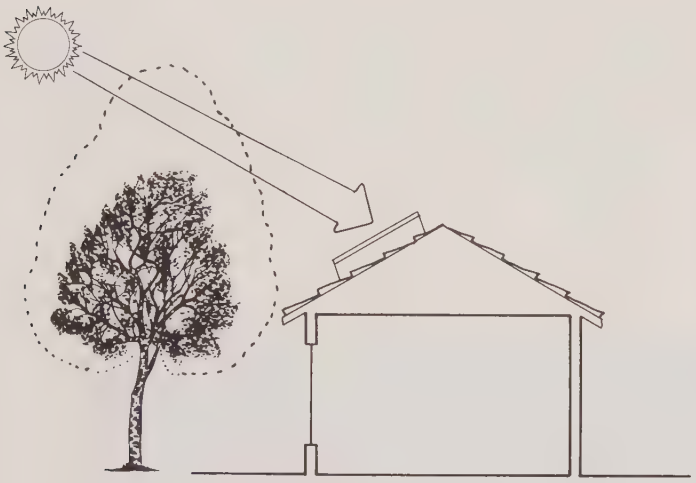
Table 7-3					
ALL OTHER ZONES MINIMUM HEIGHT OF BOTTOM EDGE OF COLLECTOR					
	Collector's Distance from Property Line				
Width of Neighbor's Lot	**5 ft.**	**10 ft.**	**15 ft.**	**20 ft.**	**25 ft.**
50 ft.	25 ft.*	22.5 ft.	21 ft.	19 ft.	17 ft.
60 ft.	27 ft.*	25.5 ft.*	23.5 ft.	22 ft.	20.5 ft.
70 ft.	31 ft.*	29 ft.*	27.5 ft.	25.5 ft.	24 ft.
80 ft.	34 ft.*	32 ft.*	30.5 ft.*	28.5 ft.	26.5 ft.

* Permission of the Planning Department (a "variance") may be needed to place a collector in this location.

If your review of the daylight planes of neighboring lots reveals that you are not assured of adequate solar access protection, you may want to consider obtaining a "solar easement" from your neighbor. A model easement is available from the Palo Alto Utilities Department Solar Program. A solar easement is a method of writing down and recording with the county an agreement you reach with your neighbors to limit their building height. As few persons intend to rebuild their homes to the maximum permitted zoning, easements may permit you to arrange even better access than the zoning laws provide.

Trees

Is that little tree to the south of your desired collector location fully grown? As we well know in Palo Alto, some trees grow very tall and live for a long time. Knowing a tree's height and shape at maturity, you can determine if that "little" tree will grow to shade your collectors or not. You can actually visualize this by using the site selector and imagining the tree as fully grown. Table 7-4 lists the typical height at maturity for various trees common to Palo Alto, and notes which trees are deciduous. Notice how the solar penetration varies between summer and winter. Keep this in mind when evaluating your solar access. If you are planting a new tree, choose one that will not shade a potential collector site. Many deciduous trees can provide passive cooling shading in the summer, while allowing passive heating in the winter.



POSSIBLE SHADING—Trees

The California Solar Shade Control Act can provide you protection from future trees. This law prohibits the placement of trees or shrubs which will shade an existing collector. It only applies to trees and shrubs planted *after* a system was installed. To qualify for protection under this law, your collectors must be placed not less than five feet from the property line and no less than ten feet above the ground. If it is installed at a height of less than ten feet, a collector may be protected only if it set back an additional three feet for each foot that it is lower than ten feet. You may wish to take a photograph of the existing trees when you install your solar system to establish a record for later use if needed.

Table 7-4

COMMON PALO ALTO TREES

		Height	Width	Growth Rate	Solar Penetration Summer	Winter
Acer Platanoides (Schwedleri)	Deciduous	25–60'	20–50'	Rapid	11%	61%
Acer Saccharinum (Silver Maple)	Deciduous	40–100'	50–100'	Rapid	14%	63%
Albizia Julibrissin (Silk Tree)	Deciduous	35–40'	60'	Rapid	13%	58%
Calocedrus Decurrens (Incense Cedar)	Evergreen	50–150'	12–50'	Slow to Moderate	6%	6%
Cinnamomum Cvamphora (Camphor Tree)	Evergreen	20–50'	30–60'	Slow	13%	13%
Cupaniopsis Anacardioides (Carrot Wood)	Evergreen	30'	20'	Slow to Moderate	5%	5%
Eucalyptus Camaldulensis	Evergreen	80–120'	40'	Rapid	11%	11%
Koelreuteria Paniculata (Goldenrain Tree)	Deciduous	20–35'	10–40'	Slow to Moderate	22%	37%
Quercus Palustris (Pin Oak)	Deciduous	50–80'	35–40'	Rapid	11%	–
Pinus Halepensis (Aleppo Pine)	Evergreen	30–60'	40'	Rapid	6%	6%
Platanus Racemosa (California Sycamore)	Deciduous	50–100'	50'	Rapid	5%	42%
Schinus Molle (Peruvian Pepper)	Evergreen	25–40'	15–70'	Rapid	15%	15%
Sophora Japonica (Japanese Pagoda Tree)	Deciduous	40'	40'	Slow	16%	32%
Ulmus Parvifolia (Chinese Elm)	Semi-deciduous	40–60'	70'	Rapid	16%	38%

Chapter 8

MATCHING THE RIGHT SOLAR SYSTEM TO YOUR ENERGY NEEDS

By estimating your household's current energy use and potential savings, you can complete your own solar energy assessment using the worksheets in this chapter. There may be reasons why the worksheet method used in this chapter cannot be used to calculate your heating load: you may have no record of your utility bills; you may heat with electricity in the winter and air-condition in the summer; or you may heat your pool year-round. Calculating the heat load in these cases is more complicated than we can explain in this guide, and you may want to arrange for a home energy survey. If you fall within one of these categories but wish to independently examine these issues, please contact us at 329-2322 for further information, or at 329-2241 for a free Residential Conservation Service (RCS) energy survey.

To make your own personalized estimate of solar energy potential, follow the steps in this chapter. All you need to perform this simple analysis is a copy of your Palo Alto Utilities bill. A basic calculator will make the calculations easier but is not essential. No difficult calculations are involved.

WHAT ARE YOUR ENERGY NEEDS?

The bottom half of the utilities bill shows your average daily consumption of water, gas, and electricity. Look at the appropriate columns depending on what type of fuel you use for water heating and space heating. You will be interested in the *amount* of energy consumed, *not* the cost of that energy. Gas is measured in *therms* and electricity in *kilowatt hours* (kWh). Use Worksheet 1 and fill it in with your average daily consumption for the past year. (If you can average available data for several years, the information will be even more accurate.) The daily consumption multiplied by the number of days in each month gives you a monthly consumption figure. The sum of all months shows how much energy you use annually. Worksheet 1 will serve as the basis for the rest of your energy calculations.

WORKSHEET 1 — ENERGY CONSUMPTION RECORD

	Natural Gas						Electricity					
	Avg. Daily	x	days in mo.	=	monthly consumption		Avg. Daily	x	days in mo.	=	monthly consumption	
Jan	_____	x	31	=	_____	therms	_____	x	31	=	_____	kWh
Feb	_____	x	28	=	_____	therms	_____	x	28	=	_____	kWh
Mar	_____	x	31	=	_____	therms	_____	x	31	=	_____	kWh
Apr	_____	x	30	=	_____	therms	_____	x	30	=	_____	kWh
May	_____	x	31	=	_____	therms	_____	x	31	=	_____	kWh
June	_____	x	30	=	_____	therms	_____	x	30	=	_____	kWh
July	_____	x	31	=	_____	therms	_____	x	31	=	_____	kWh
Aug	_____	x	31	=	_____	therms	_____	x	31	=	_____	kWh
Sept	_____	x	30	=	_____	therms	_____	x	30	=	_____	kWh
Oct	_____	x	31	=	_____	therms	_____	x	31	=	_____	kWh
Nov	_____	x	30	=	_____	therms	_____	x	30	=	_____	kWh
Dec	_____	x	31	=	_____	therms	_____	x	31	=	_____	kWh
Total Annual Therm Use				=	_____	therms	Total Annual kWh Use			=	_____	kWh

WHERE DOES YOUR ENERGY GO?

The next step is to figure out how much of your energy consumption serves each function in your home. Once you figure out your energy uses, you can look at possible ways of meeting them through solar energy. If you foresee any changes in your energy needs (e.g., more or fewer people living in the house or the addition of a clothes dryer), you can adjust your current energy usage to account for these changes (contact us for information on how to do this). For appliances, you can do so by requesting our publication *Homeowners, It's Your Utility Bill* and incorporating the changed energy amounts into your calculations. Energy use is divided into two groups: the *heating load* is energy used for space heating; and the *base load* is energy used for everything else.

Heating Load

The energy used for space heating can be calculated by subtracting out the "base load" from your total energy consumption. To figure your base load, look at how much energy you use during the summer months when you are not space heating. Use Worksheet 2 below to figure out your base load and heating load. Use your gas or electric data, depending on which energy source supplies your space heating.

Water Heating

If you use gas for both water heating and space heating, your water heating energy use can be calculated from the base load you figured in Worksheet 2. If you have a gas water heater and electric space heating, then your total annual gas use is your base load. In either case, turn to Worksheet 3 to figure energy use for water heating with natural gas. If you have an electric water heater, the Worksheet 3 method does not work because it is difficult to separate the energy used to heat water from that for lighting, refrigerators, etc. A good alternative in this case is given by the formula below:

Electricity used for water heating = 1250 kWh x number of people in household + 600 kWh.

To convert to therms, multiply kWh x .034.

Swimming Pool Heating

If you have a swimming pool, it may be difficult to determine the amounts of gas you use for pool heating and space heating. If you have any month when you heated neither your pool nor your home, you can use that as a monthly base load figure and calculate heating loads based on that. Your summer gas use minus the base load should show your pool heating consumption, or you can look back at your utilities bills prior to installing your pool and compare that usage to your present usage with a pool.

If neither of these methods works, you can use figures typical for this area. The average annual gas consumption for pool heating in Palo Alto is about 790 therms. Accounting for burner inefficiency, this means a net energy use of 550 therms. (Note: This number is a rough estimate. Be cautious about using this figure when calculating your energy consumption for water heating or space heating.)

WORKSHEET 2

ENERGY USE FOR SPACE HEATING WITH NATURAL GAS (OR ELECTRICITY)

1. Enter your natural gas (or electric if you use electric heat*) Total Annual Energy Use from Worksheet 1.

(1) _____ therms (kWh)

2a. For the same energy savings listed in line 1, enter energy used during each month you did *not* use your furnace:

May _____
June _____
July _____
Aug _____
Sept _____
Oct _____

Total _____(2a)

2b. Divide the total by the number of months you filled in in 2a. This gives you the average use for a non-heating month.

_____ ÷ _____ = _____ (2b)
(2a) no. months

2c. Multiply line 2b by 12

_____ x 12 = (2c) _____ this is your BASE LOAD
(2b)

3. Subtract line 2c from line 1

(3) _____

4. Multiply line 3 by a factor to account for the efficiency of the heater.

If gas heat: _____ x .7
(3) (efficiency)

If electric heat: _____ x 1.0
(3) (efficiency)

(4) _____ therms (kWh)
This is your Net Annual HEATING LOAD

* Natural gas is measured in therms.
Electricity is measured in kilowatt hours.

Based on *Solar for Your Present Home*.

WORKSHEET 3

ENERGY USE FOR WATER HEATING WITH NATURAL GAS

1. Annual gas BASE LOAD
   (from Worksheet 2, line 2c) (1) _____ therms

2. Adjustments for other uses of gas:

   a. Cooking:
      Enter 100 for gas stove with pilot lights,
      60 for gas stove without pilot lights,
      zero for electric stove. (2a) _____

   b. Clothes dryer:
      If you have a gas dryer, calculate as follows:

      $7.8 \times \frac{\text{_____}}{\text{no. of loads per week}} =$ (2b) _____

   c. Furnace pilot light correction. If your furnace has a pilot light, it consumes about 7 therms each month it burns. Enter the number of months per year your furnace pilot light is on.

      $\frac{\text{_____}}{\text{No. of months}} \times 7 =$ (2c) _____

      Total Adjustments (2a + 2b + 2c) = (2) _____

3. Subtract line 2 from line 1. (3) _____

4. Burner inefficiency correction. Only 70% of the heat from the burning gas actually warms your water (the rest goes up the flue).
   Multiply line 3 by 0.70.

   $\frac{\text{_____}}{(3)} \times 0.70 =$ (4) _____ therms
   Net Energy use for WATER HEATING LOAD

Based on *Solar for Your Present Home.*
(The California Energy Commission and Berkeley Solar Group)

HOW CAN YOU MATCH SOLAR TO YOUR ENERGY NEEDS?

Now that you have figured out your energy needs, you will want to know what portion of those needs could be met with a solar system. The amount of energy provided by a solar system is determined by the collector area and the amount of sunlight striking that area. Comparing the energy collected to your energy needs as calculated in the previous section will show your expected savings. The next chapter, Solar Economics, can help you determine whether a solar system that provides these savings is a wise investment for you.

The following calculation methods can be used to estimate your possible savings with each type of system. Work through the section covering the type of system you are considering. Our graphs were computed using certain assumptions about system type and installation, following the guidelines we have recommended throughout this booklet. Savings are estimates, derived specifically for Palo Alto's climate. Actual savings you achieve with a solar system will probably differ.

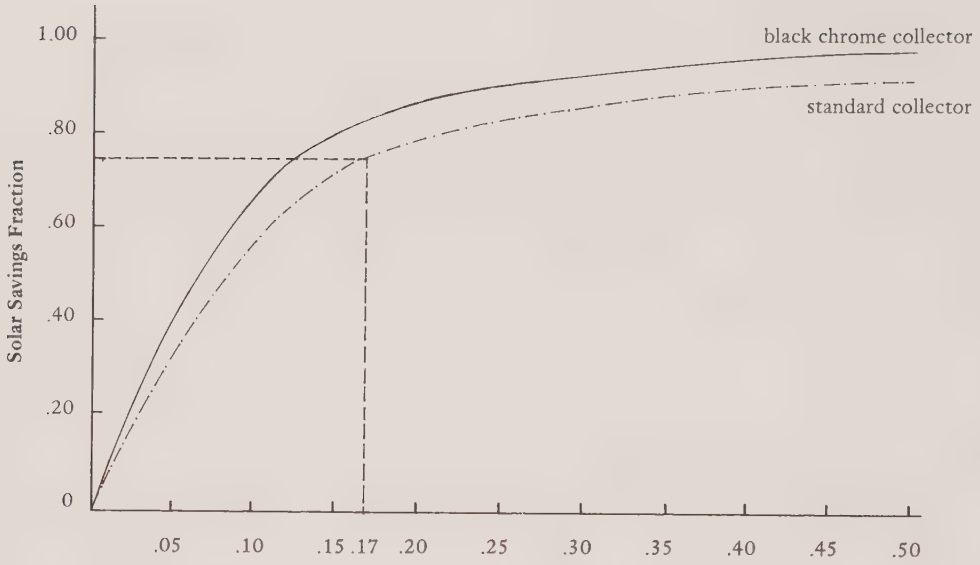
WORKSHEET 4

SAVINGS FOR SOLAR DOMESTIC HOT WATER, WHOLE HOUSE ACTIVE SPACE HEATING, OR PASSIVE SPACE HEATING

	Example of Hot Water System	Yours:
1. Calculate collector area based on our rules of thumb or a contractor's estimate. (Number of collectors x size of each collector.) For a passive system, collector area would be total south window area.		
Example for hot water system:		
2 panels, size 4 ft x 8 ft = 2 x (4 x 8) = 64 ft	(1) 64	
2. Determine your *Solar Access Fraction*. This is the percent of time between 10 a.m. and 2 p.m. that your collector area is unshaded. (See Chapter 9 on Solar Access.) Express your solar access as a decimal. (If the area receives sunlight 95% of the time, your solar access fraction is 0.95.)	(2) .95	
3. Multiply line 1 by line 2.	(3) 61	
4. Enter your present energy needs for the type of heating you are trying to displace. Water heating (get water heating load from Worksheet 3, line 4), or space heating (get heating load from Worksheet 2, line 4).	(4) 360 therms	therms
5. Divide line 3 by line 4. This results in a factor which allows you to use the graphs below to determine your solar savings.	(5) .17	
6. Select the appropriate graph 1, 2, or 3 below that corresponds to the type of solar system you are considering. On the bottom axis of the graph, locate the value from line 5. Draw a straight line up to intersect with the performance curve of your system type. Draw a second line directly to the left-hand axis. Where this line intersects, the left axis defines "solar savings fraction," the percentage of your load which could be provided by the solar system. Enter your solar savings fraction on line 6. (In our example, we look at a standard collector.)	(6) .75	
7. Multiply your solar savings fraction by your energy load (line 6 x line 4). The result is your expected annual energy savings from that solar system. (Example: 0.75 x 360 = 270)	(7) 270 therms	therm savings

GRAPH 1

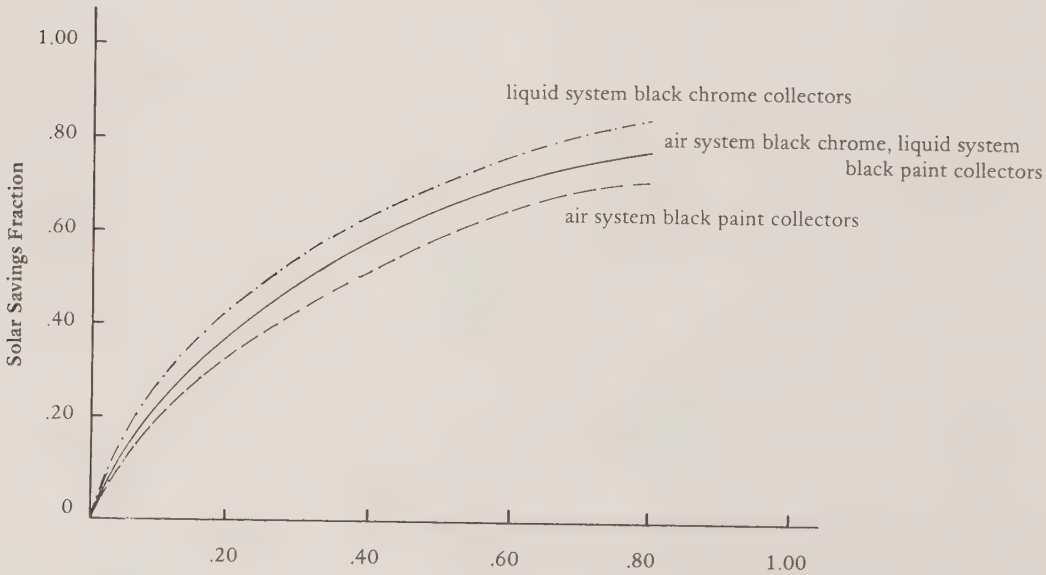
DOMESTIC WATER HEATING PERFORMANCE



$$\frac{\text{Collector Area x Solar Access Fraction}}{\text{Water Heating Load}} = \text{the value determined in Step 5 of Worksheet 4.}$$

GRAPH 2

WHOLE HOUSE ACTIVE SOLAR SPACE HEATING PERFORMANCE

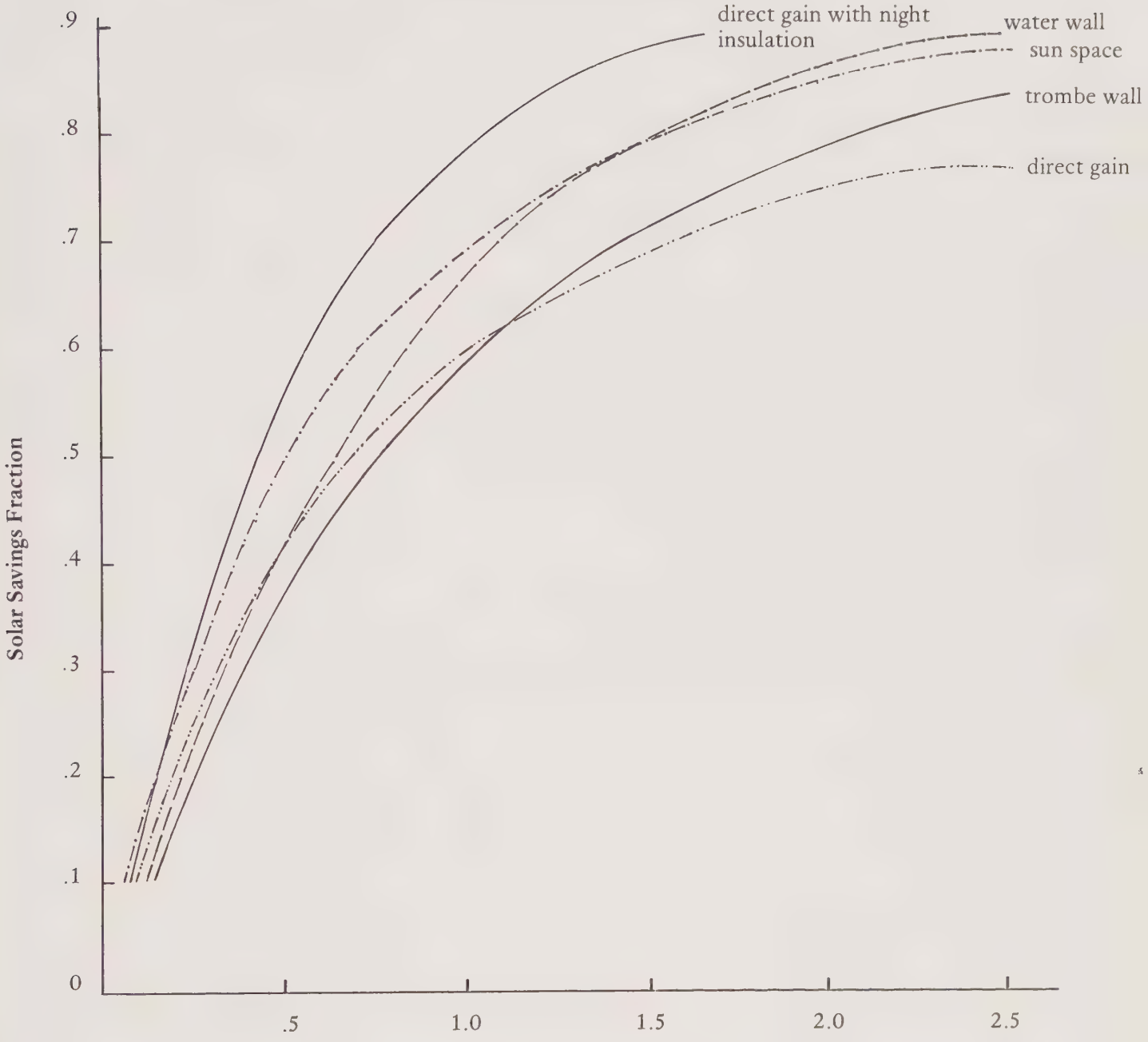


$$\frac{\text{Collector Area x Solar Access Fraction}}{\text{Heating Load}} = \text{the value determined in Step 5 of Worksheet 4.}$$

GRAPH 3

PASSIVE SOLAR SPACE HEATING PERFORMANCE

(assumes adequate thermal mass in home)



$$\frac{\text{Collector Area} \times \text{Solar Access Fraction}}{\text{Heating Load}} = \text{the value determined in Step 5 of Worksheet 4}$$

WORKSHEET 5

SAVINGS FOR A COMBINED SOLAR SYSTEM: DOMESTIC HOT WATER WITH A ROOM HEATER

A solar hydronic room heater can be connected to a solar domestic hot water system to provide heat for a specific room in your home. Typically, one additional collector panel is used for each room heater, and a larger storage tank is required. The expected savings for water heating and space heating can be estimated as follows:

1. Calculate collector area based on our rules of thumb or a contractor's estimate. (1) _____

2. Determine your solar access fraction (the percent of time between 10 a.m. and 2 p.m. that your collector area is unshaded). (2) _____

3. Multiply collector area times solar access fraction (line 1 x line 2). Multiply result by 5. (Approximately 5 therms of energy are provided by each square foot of collector.) (3) _____ therms

   This shows how much energy is provided directly by the solar system. However, if a room heater is used for your most frequently occupied room, you may be able to achieve much greater savings. A room heater allows you to maintain comfortable temperatures in a specific zone in the house, while lowering the thermostat setting for the rest of the house. This would result in further savings. Steps 4 through 7 help you calculate energy savings due to lowering the temperature of the rest of the house, while keeping the solar heated room at the higher temperature.

4. What is your current winter thermostat setting? (4) _____ °F
   Expected reduced setting? _____ °F

5. Find corresponding savings fraction from Chart 5 below. (For example, reducing your thermostat from 72° to 68° would reduce your heating bill by about 26%.) (5) _____

6. Enter your space heating load (from Worksheet 2, line 4). (6) _____

Fraction of Heat Saved Due to Lowering Thermostats

Current Setting (°F) \ Lowered Setting (°F)	74°	72°	70°	68°	66°	64°	62°	60°	58°	56°
76°	.10	.18	.27	.40	.50	.59	.68	.75	.82	.87
74°	x	.10	.19	.33	.45	.54	.65	.73	.80	.86
72°	x	x	.11	.26	.39	.50	.61	.70	.78	.83
70°	x	x	x	.17	.32	.43	.57	.66	.76	.87
68°	x	x	x	x	.18	.32	.47	.59	.71	.79
66°	x	x	x	x	x	.20	.36	.50	.64	.74
64°	x	x	x	x	x	x	.23	.40	.57	.69
62°	x	x	x	x	x	x	x	.23	.44	.60
60°	x	x	x	x	x	x	x	x	.28	.48

7. Multiply savings by heating load (line 5 x line 6). This is your savings due to resetting the thermostat. (7) _____

8. Figure total savings (line 3 + line 7) (8) _____

WORKSHEET 6

SAVINGS FOR A SOLAR SWIMMING POOL SYSTEM

The amount of energy that you use and can save for pool heating depends on your pool heating season, the temperature at which you keep your pool, and whether or not you use a pool cover. Table 8-1 below shows what the gas use and potential solar savings might look like for an outdoor pool in Palo Alto. We assumed the pool was kept at 80° F and that, in the pool example, the pool cover was kept on from 6 p.m. to 8 a.m. Figures shown are per square foot of pool surface area. We generally recommend a collector area equivalent to 60% of the pool surface area if using unglazed collectors, or 40% of the pool surface area for glazed collectors.

Table 8-1

POOL HEATING GAS USE AND POTENTIAL SAVINGS
(therms per square foot of pool surface area per year)

	Swim Season			
	June-Aug.	May-Sept.	April-Oct.	Year-Round
UNCOVERED POOL				
Gas Use	1.6	3.1	5.0	12.0
Gas Use with Solar	.8	1.8	3.3	9.5
Solar Savings	.8	1.3	1.7	2.5
COVERED POOL				
Gas Use with Cover	0	.5	1.1	4.7
Gas Use with Solar and Cover	0	0	.4	3.6
Solar Savings	0	.5	.7	1.1

If you do not currently use an insulated pool cover, note the dramatic difference in gas use for an uncovered pool. Depending on your swimming season, you could accomplish most or all of your heating with a pool cover.

You can use Table 8-1 to estimate your potential solar savings if your pool-use pattern is consistent with our assumptions. Find your savings per square foot of pool surface area based on your swim season and cover use. We give an example for a 540-square foot (18 feet by 30 feet) swimming pool. The pool is currently uncovered and the swim season is from April to October. The collector area needed for unglazed collectors is 60% of 540 square feet, or 320 square feet.

1.	Calculate pool surface area: (length x width) Example: 18 ft. x 30 ft. = 540 sq. ft.	1. 540 sq. ft.	_____ sq. ft.
2.	Calculate your collector area: Glazed collectors = .40 x pool surface Unglazed collectors = .60 x pool surface Example: .60 x 540 = 320 sq. ft.	2. 320 sq. ft.	_____ sq. ft.
3.	Select Savings Rate from Table 8-1 based on your swim season and cover use. Example: Savings rate for April-Oct. swim season, uncovered pool = 1.7 therms/sq. ft.	3. 1.7 therms/ sq. ft.	_____ therms/ sq. ft.
4.	Calculate your savings: (line 1 x line 3) Example: 540 sq. ft. x 1.7 therms/sq. ft. = 918 therms.	4. 918 therms	_____ therms

These are your yearly gas savings with a solar pool heating system.

Chapter 9

UNDERSTANDING SOLAR ECONOMICS

You have now estimated where your energy dollar is going and how much energy you might expect a solar system to provide. The next step is to examine the economics of a solar system that will meet your needs. Here we offer a step-by-step procedure to help you approximate the estimated energy cost savings. Here as before, your actual savings will probably differ from these general figures. For each step, we will work through an example for a hypothetical Palo Alto family which purchased a solar domestic water heating system. You may wish to keep your answers to each step on a separate sheet of paper so you can easily refer to them.

STEP 1: Price

The price of a solar system can vary among contractors and suppliers. You can use the typical costs identified in the preceding sections or obtain estimates from contractors yourself.

		Example	Yours
1.	System Cost:	$3,500	_____

STEP 2: Tax Credits

Both the federal government and the State of California offer tax credits for many of the residential solar energy systems mentioned in this booklet. *A tax credit is subtracted directly from the income taxes you would pay* (the amount withheld from your paycheck) — *it is not a deduction from your income.* If you cannot use all of a tax credit the first year, you may carry the balance forward.[1] However, *if you do not have any taxable income, you will not be able to take advantage of these tax credits.* Table 9-1 below reflects tax credits available in August 1983. They are subject to change. Be sure to check with the Internal Revenue Service (IRS), the State Franchise Tax Board, or your accountant to verify available tax credits and your eligibility at the time you plan to purchase a solar system.

Table 9-1

TAX CREDITS*

Application	State		Federal		Combined	
	Percentage	Maximum	Percentage	Maximum	Percentage	Maximum
Passive space heating	50%	$3,000	0	0**	50%	$3,000
Passive space cooling	50%	$3,000	0	0**	50%	$3,000
Water heating	50%	$3,000	40%	$4,000	50%	$7,000
Active space heating	50%	$3,000	40%	$4,000	50%	$7,000

* As of August 1, 1983. Call us or your tax advisor for up-to-date tax credit information.

** Some applications may qualify, as we discussed in the preceding chapters. Consult your tax advisor if you have questions.

[1] Note: If you install a solar system between August 1, 1983, and January 1, 1984, you are required to split your state solar tax credit over the following two years. This restriction only applies to systems installed during this five-month period. You may claim the full federal tax credit in the first year.

The state tax credit is available for each separate *function* the system performs. A system which provides both space *and* water heating may qualify for a $6,000 maximum. The state distinguishes six different solar functions: water heating (for home or recreation), space conditioning (heating or cooling), production of electricity, process heating, solar mechanical energy, and wind energy.

An active solar space or water heating system may be eligible for both state and federal tax credits. When both federal and state credits are claimed for the same expenses, the combined credits may not exceed the percentage of the California credit. The federal credit must be deducted from the maximum state credit to result in the allowable claimed state tax credit. We have worked out an example for you and then given you a chance to calculate your own estimated tax credits.

		Example
2a.	System cost (from Step 1)	$3,500
2b.	Maximum State Tax Credit (50%) (line 2a x .50)	1,750
2c.	Federal Tax Credit (40%) (line 2a x .40)	-1,400
2d.	Allowable State Tax Credit which can be claimed (line 2b - 2c)	350

Please note that your state tax credit is considered income for federal tax purposes. This will effectively reduce the total value of the state tax credit. If you are in a 30 percent marginal federal tax bracket, this means:

2e. Federal tax on state credit = .30 x $350 = $105.00.

2f. Total state and federal credit will be:
($350 - $105) + $1,400 = $1,645.00
2d 2e 2c 2f

State Credit - Federal Taxes + Federal Credit = Net Tax Credit

2g. Therefore, the net system cost after tax credits = $3,500 - $1,645.00 = $1,855.00
2a 2f 2g

In effect, half the system cost would be returned through tax credits in this example. Calculate your net system cost below:

2a.	System installed cost	$_____
2b.	Maximum state tax credit (line 2a x .50)	$_____
2c.	Federal tax credit (line 2a x .40)	$_____
2d.	Allowable state tax credit (2b - 2c)	$_____
2e.	Federal tax on state credit (your marginal tax bracket x 2d)	$_____
2f.	Total tax credit (2d - 2e) + 2c	$_____
2g.	NET SYSTEM COST (2a - 2f)	$_____

More detailed discussion, information, and regulations on the tax credits and eligibility criteria can be obtained from the Internal Revenue Service (IRS) and State Franchise Tax Board (FTB).

The City of Palo Alto offers a 10 percent discount off residential customers' electric bills if an eligible solar space or water heating system has been installed. You can obtain more information on this discount from the Utilities Solar Program staff (329-2322).

STEP 3: Financing

Most people will finance the cost of solar systems. Therefore, monthly loan payments should be partially (or totally) offset by utilities bill savings. If you are building a new home, consider including the cost of solar systems in your home mortgage, or, if you are modifying your present home, many local lending institutions will make home improvement loans or personal loans for solar energy systems.

The City of Palo Alto Solar Program also offers low-interest financing for Palo Alto residents to install any eligible solar water heating system, active space, and pool heating systems. All residents who are City of Palo Alto Utilities customers are eligible to apply. These low-interest loans can be particularly attractive as the total cost of a solar system can be financed and repayment is through the utilities bill for up to ten years in term. For specific loan information, contact the Solar Financing Program (329-2322).

Special low-interest loans may also be available to low or moderate income Palo Alto homeowners through the City's Building Division. This Housing Improvement Loan Program may cover solar system additions. To determine whether you qualify, contact the Housing Improvement Program (329-2513).

Table 9-2 below shows what your loan payments would be for each $1,000 that you borrowed at various interest rates and loan terms. To calculate your annual loan payments, first select from the table the annual loan payment which corresponds to the interest rate and loan term you are considering. Multiply this by the multiple of $1,000 which reflects the loan amount you plan. For example, $3,000 borrowed at 8% for 10 years requires a payment of: (value from table) x ($3,000 ÷ $1,000) = $146 x 3 = $438/year.

Table 9-2

ANNUAL LOAN PAYMENTS FOR A $1,000 LOAN

Interest rate	Term 5 years	10 years	15 years
8%	$243	$146	$115
10%	255	159	129
12%	267	172	144
14%	279	186	160
16%	292	201	176

Calculate your solar financing costs the same way. If you are not borrowing the full amount, include the amount of cash down payment on line 3g. Keep in mind that interest payments for a loan are tax deductible, which will, in effect, reduce the total cost of your system. (We do not show the tax deduction in our example.)

	Example	Yours
3a. Loan amount	$3,000	$ _____
3b. Loan interest rate	8%	_____ %
3c. Loan term (years)	10	_____
3d. Value from table	$ 146	$ _____
3e. Loan amount (line 3a) divided by $1,000	3	_____
3f. Annual loan payment (3d x 3e)	$ 438	$ _____
3g. Net cash needed (2a - 3a)	$ 500	$ _____

STEP 4: Valuing Your Solar Savings

A solar energy system can save you energy and money on your utilities bill. To calculate the estimated dollar savings, you will need some of the information you calculated in Chapter 8. If you can obtain information regarding the estimated additional electricity consumption of any system pumps and controls, include this in your figures below. (A standard 1/12 hp active solar system pump will generally consume about 150 kWh per year). The solar system's own energy consumption should be subtracted from the system's savings to determine the net energy savings. After calculating the first-year savings, the next step will account for future fuel price increases which will improve your savings over time.

		Example		Yours
4a.	Annual fuel savings with solar system (as calculated in Chapter 8)	270	Therms (or kWh)	_____
4b.	Annual electricity needed to operate system	150	kWh	_____
4c.	Price of natural gas*	$ .65	$/therm	$_____
4d.	Price of electricity*	$ .026	$/kWh	$_____
4e.	Annual fuel cost savings (line 4a x appropriate fuel cost)	$ 175		$_____
4f.	Electric cost to operate system (line 4b x 4d)	$ 3.90		$_____
4g.	Net first-year solar savings (line 4e - 4f)	$ 171.10		$_____

* These are average fuel prices as of August 1983. If your consumption is high, your average savings rate will be higher. Consumption below the "lifeline" level will correspond to a lower savings rate.

STEP 5: Lifetime Solar System Costs and Savings

The lifetime savings from your solar system can vary depending on what happens to fuel prices. As fuel prices continue to increase, your monetary savings from the solar system become more significant. To figure out the amount your solar system will save over its life, select what you believe to be an appropriate lifetime for your system and a percentage rate at which you expect fuel prices to increase each year. Find the corresponding "savings escalation factor" from Table 9-3 below. This factor multiplied by your first-year savings gives you the expected lifetime savings. (Lifetime savings = Savings Escalation Factor x line 4g.) Write the results on line 5b. Example: assuming a 20-year solar system life and fuel price increases of 10 percent per year, lifetime savings = 57 x $171.10 = $9,752.70

Table 9-3

SAVINGS ESCALATION FACTOR

System Life (yrs.)	Annual Fuel Price Increases (%) 5	8	10	12	15	20
10	13	14	16	18	20	26
15	22	27	32	42	37	72
20	33	46	57	72	102	187
30	66	113	164	241	345	1,181

Generally, people anticipate the following lifetimes for different solar systems: pool system—10 to 15 years; domestic water heating system—20 to 30 years; active space heating system—20 to 30 years; and passive solar system—the life of your home. Of course, a well-maintained system may last longer. Maintenance factors are not assumed in this formula.

The City of Palo Alto Utilities Department currently (August 1983) estimates that fuel rates will increase by an average of 15 percent each year (including inflation) for the next ten years. You may wish to use higher or lower numbers depending on your view of the energy picture.

The lifetime cost of your solar system is the total of all of your loan payments plus the original cash outlay to purchase the system, minus the tax credit. Multiply your annual loan payment (line 3f) by the term of your loan (line 3c). Add the net cash downpayment. Subtract the tax credit (line 2f).

Write your answer on line 5a. For our example, it is ($438 x 10) + $500 - $1,645.00 = $3,235.00.

Lifetime Solar Costs and Savings

		Example:	Yours:
5a.	Lifetime purchase cost (3f x 3c) + 3g - 2f	$3,235.00	$ _____
5b.	Lifetime energy savings (savings escalation factor x line 4g)	$9,752.70	$ _____
5c.	Net lifetime cost savings (5b - 5a)	$6,517.70	$ _____

If line 5c is positive, then the solar system could save you this amount of money over the cost of the system. If line 5c is negative, then this particular solar system may not make economic sense for you, and you should investigate a do-it-yourself installation, less expensive financing techniques, or some other solar options. The above analysis has allowed you to determine whether a solar system will save you money over its useful life. However, if you are interested in seeing your solar economics on a year-by-year basis, you may wish to perform a cash flow analysis as discussed in Appendix A.

Based on Solar Domestic Hot Water (New York State)

Chapter 10

DOING-IT-YOURSELF OR SELECTING A CONTRACTOR – WHICH IS FOR YOU?

Whether you decide to install the system yourself or hire a contractor, the City of Palo Alto has services to assist you in obtaining a quality solar system. The Utilities Department Solar Program staff is available to answer any questions you have about solar energy systems. We can also perform a technical evaluation of system plans to see if the sizing, location, and layout of the proposed system look appropriate.

Whether you plan to hire a contractor or install a system yourself, there are several general considerations to keep in mind.

- Shop carefully for solar equipment. You may not actually save money by buying a lower priced system. In systems that utilize glazed flat-plate collectors, the collector panel is a crucial component which can affect the overall system efficiency. All solar panels sold in California for water heating have been tested under the Solar Rating & Certification Corporation (SRCC) or the Testing and Inspection Program for Solar Equipment (TIPSE). These state-certified rating methods provide consumers with reliable and comparative information on solar collector performance. The programs are similar to the federal automobile fuel efficiency tests (e.g., "EPA-rated at 36 m.p.g.") in that actual performance may not be at test levels, but the tests do offer a method of relative comparison. System efficiency figures can allow you to determine a dollar per Btu value for various collectors. Sometimes a lower efficiency can be countered by more or larger panels that may be less expensive. The SRCC and TIPSE test results are available for your reference at the City of Palo Alto's Solar Program Office and at the Energy Information Center (Main Library).

- The installation of your system can affect its annual and seasonal performance. Follow the guidelines discussed in this booklet for the tilt and orientation appropriate for each type of system.

- Try to retain the aesthetic qualities you value for your home. There is some trade-off between optimal performance and your solar system's aesthetic appearance. However, keep in mind that as long as you stay within the guidelines we discussed for tilt, orientation, and solar access, you have considerable leeway in installing your system. Install the system so that it is visually pleasing. The City of Palo Alto has visual guidelines to assist you.

DO-IT-YOURSELF

If you are a do-it-yourselfer, a solar system may be a good project for you and you may save quite a bit of money.

- If you are already handy with tools or have construction experience, you may be ready to install your own solar energy system. Many solar systems are easy to build or install using conventional building tools, components, and techniques.

- If you do not have any experience, the City of Palo Alto and many local colleges and adult education programs offer one- to two-day courses on solar energy system installation which could provide an introduction to these options.

In either case, you may wish to use the following services:

- The City of Palo Alto's Solar Program has design and installation specifications for solar systems which can assist you in designing your system.

- The Energy Information Center at the Palo Alto Main Library also contains an excellent collection of books including information on products, designs, and installation techniques.

If you are installing a system in your own home, you do not need a contractor's license. Owner-installed systems qualify for the tax credits as long as the tax credit regulations are followed, including obtaining the necessary building permits. The City's Solar Program staff can review your plans with you to see that you meet building permit and tax credit requirements.

ACTIVE SYSTEMS

Installing an active solar system requires basic skill in carpentry and plumbing (including soldering). You can purchase individual pieces of equipment or complete kits. The additional cost of a complete kit is minimal, and the added ease of construction can be great. In either case, the manufacturer's installation instructions must be followed, since installation that does not follow the manufacturer's specifications may invalidate the warranty. Hands-on training courses for the installation of solar systems are frequently offered in this area.

PASSIVE SYSTEMS

Installing passive space conditioning can also be a good project for a do-it-yourselfer. Many passive options mentioned in this booklet are suitable for owner installation.

Keep in mind that installing your own passive system will take a fair amount of time. The savings can be great, but be sure that you have the time to spend before you begin a major project.

CONTRACTOR SELECTION

The solar industry is growing, with new companies constantly entering the field. While most solar contractors are highly responsible, the fact remains that consumer complaints against contractors (of all kinds) continue to be a concern in California today. A solar system can be a major purchase, and you should carefully select your installer. We recommend that you take the following steps in selecting your contractor:

- Get contractors' names (preferably from friends who are pleased with their solar systems) from the Yellow Pages or the "City of Palo Alto Solar Contractor's Survey." (Please note that the appearance of a name on a Palo Alto list does not constitute a recommendation or endorsement by the City.)

- Talk to and get estimates from several contractors.

- Deal only with companies with whom *you* will feel comfortable in working out the design of your system.

- The contractor should do a solar site assessment and be willing to design a system specifically for your home.

- Deal only with licensed contractors who will back their work with warranties which meet tax credit requirements.

- If you wish to have insurance against system failure in the event the contractor goes out of business, you can require your contractor to provide you with a bonded warranty from CALSEAL. Contractors who offer this service are listed on Palo Alto's contractors' list.

- Find out how long the contractors have been in business and how many solar systems they have designed and installed. Ask for names and addresses of previous local jobs which you can inspect and call the owners or go take a look at the systems. Call the Contractor's State Licensing Board in San Jose to see if particular contractors have had any complaints or administrative actions filed against them.

- Ask for an advance copy of contractor's or manufacturer's solar system operating manual (for active systems) and review it. Discuss maintenance procedures.

- Ask for estimated energy and dollar savings provided by the system.

- Get a written contract with a complete description of the system components and a specified price, as well as installation start and completion dates.

- Before you choose a contractor to install your solar system, contact the Utilities Solar Program for an objective review of the proposals' merits.

- On your contract, you may want the contractor to certify that the installation will meet appropriate building codes and the Palo Alto Solar Financing Program's *Design and Installation Specifications* (copies of which are available from the Solar Program Office).

- Once the system has been installed, it should be thoroughly tested by the contractor. The Palo Alto Building Division will also inspect it for compliance with health and safety requirements.

CONCLUSION

We hope this guidebook has helped you examine your opportunities to use solar energy for your home. You have probably found that some kind of solar system makes economic sense for you.

The Palo Alto Utilities Department hopes to see 3,000 solar systems in the community in 1986, providing energy for water heating, space heating, and pool heating. This significant effort to tap our local energy resources would reduce the community's future requirements for conventional energy supplies. The use of solar not only brings immediate energy bill reductions to consumers with solar systems, but also can minimize the utility bills of all customers as Palo Alto reduces its purchases of increasingly expensive conventional energy sources.

We are *your* Utilities Department. As part of your City Government, the Utilities Department is owned by you. You are our customers and our stockholders. The Solar Program was developed to help you evaluate your solar energy options and move forward with your choices. We invite you to take advantage of some of the services available to you:

- answers to questions about solar energy systems and further details about topics covered in this booklet,
- assistance in the technical and financial feasibility of solar for your home,
- free review of plans for your proposed solar system,
- a low-interest loan program to help overcome the initial expense of a solar energy system,
- workshops and classes teaching the basics of solar technologies and offering hands-on experience,
- an "Energy Information Center" at the Main Library which includes a collection of some excellent books on conservation and solar energy.

If we can assist you in any way, please feel free to call us at 329-2322.

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Appendix A

A CASH FLOW ANALYSIS ALTERNATIVE

A cash flow analysis is an effective tool for analyzing the year-by-year costs and benefits associated with your solar investment. Additional variables, such as income tax deductions for interest payments, can be included in such an analysis.

In a cash flow table, a negative number in a cash flow column indicates an outflow of cash. A positive number means a savings. The cumulative cash flow column shows the year-to-date status of your investment. Once this number is positive (and stays positive), the system is providing a long-term profit for you.

The instructions below are provided for each year. You will need to use the numbers you calculated for Steps 1 to 5. A sample cash flow analysis is shown in Table A-1.

YEAR 0

The Year 0 line registers only the cash expenditure (from Chapter 9, line 3g) to buy your system. Therefore, columns 1 through 5 are all zero. Your cash expenditure is equal to the total installed cost of the solar system (line 2a) minus any borrowed amount (line 3a). Write the cash expenditure in column 6. Column 7 is the tax credit which is not taken until year 1. Therefore, column 7 is also zero. Column 8, yearly cash flow, is equal to columns 1 - 2 - 3 + 5 - 6 + 7. Column 9 equals the sum of all the column 8's to date. (See the sample calculation in Table A-1 below.)

YEAR 1

This is the first full year of operation. You have already calculated the first-year fuel savings (line 4g). Before filling in columns 2 and 3, you will need to find out from your lender (for this information on City loans, call 329-2322) how much is repayment of the loan amount (or principal) itself. With that information, fill in the loan principal and loan interest payments for the first year of the loan (columns 2 and 3). In our example, first-year principal is $206 and first-year interest is $232.

Check the information booklet which accompanies your federal and state income tax forms to determine what tax bracket you are in. In our example, we have assumed that the family buying the solar system is in the combined 40 percent marginal tax bracket. Because our example family can deduct the loan interest payments from their income before figuring the tax owed, they save 40 percent of that interest payment in the form of reduced state and federal taxes. (This savings is available only if you itemize your deductions.) Write your tax rate as a decimal (e.g., 40% = .40) in column 4. Tax savings (column 5) is equal to columns 3 x 4 or $232 x .40 = $93 , in our example. There is no cash expenditure other than that made in year zero. Therefore column 6 is 0. The tax credit has already been calculated in line 2f. The credit is now written in column 7. The tax credit in our example is $1,645. Column 8, yearly cash flow, is the sum of all the inflows and outflows listed in the previous columns. It is calculated as columns 1 - 2 - 3 + 5 - 6 + 7 or 171 - 206 - 232 + 93 - 0 + 1,645 = $1,471. Column 9, the net cumulative cash flow, is the sum of all the column 8's up to and including the year in question. For year 1, it is the sum of column 8 for year 0 and column 8 for year 1, or -500 + 1,471 = $971 in our example.

YEAR 2

There is one important new step in the calculation of year 2. Fuel prices have risen during the year, and therefore fuel savings from use of the solar system have increased. In our example, we assumed an annual increase in fuel price of 10%. Therefore, we multiply the fuel savings in year 1 ($171) by 1.10 (i.e., 1 + 10% as a decimal) to get the fuel savings in year 2. If you believe that fuel prices will increase at a different rate each year, you can use a different multiplier each time you calculate this figure. All other calculations in year 2 are done as they were in year 1. Remember, the tax credit is taken in year 1 only, so column 7 will be zero.

YEARS 3 TO 20

Each following year is calculated just as the previous years have been, as shown in the example in Table A-1. Remember to carry out the calculations only for the number of years you expect your system to last, or 20 years in our example. By checking column 9 you can see how much money you have saved in total up to the end of each year. Remember, this savings is an estimate, and if fuel prices change at a different rate than you assumed, your actual savings will be different. In our example, the initial cash outlay is recovered immediately, through the tax credit. The first-year and lifetime savings in the example in the table are greater than had been calculated in Step 5 because of the added savings from deducting interest payments.

The economic analyses presented here can give you an accurate estimate of the financial impact of using a solar system. Reality will not, of course, conform exactly to these calculations as weather, inflation, and other factors will vary in ways impossible to predict. You may want to alter the financial analysis to account for other variables that are important to you or will affect you. For example, if you want to discount your cash savings for inflation, or consider possible alternative earnings from investing these savings, you can add another column on the worksheet.

Table A-1

CASH FLOW ANALYSIS

Column	1	2	3	4	5	6	7	8	9
Year	Fuel Savings	Loan Principal	Loan Interest	Federal and State Income Tax Rate (as a decimal)	Income Tax Savings (3 x 4)	Cash Expenditures	Tax Credit	Yearly Cash Flow 1 - 2 - 3 + 5 - 6 + 7	Cumulative Cash Flow (Sum of Col. 8 to Date)
0	0	0	0	N/A	0	500	0	-500	-500
1	171	206	232	.40	93	0	$1,645	1,471	971
2	188	223	215	.40	86	0	0	-164	807
3	207	241	197	.40	79	0	0	-152	655
4	228	258	180	.40	72	0	0	-138	517
5	250	280	158	.40	63	0	0	-125	392
6	275	307	131	.40	52	0	0	-111	281
7	303	329	109	.40	44	0	0	-91	190
8	333	359	79	.40	32	0	0	-73	117
9	366	385	53	.40	21	0	0	-51	66
10	403	420	18	.40	7	0	0	-28	38
11	443	0	0	N/A	0	0	0	+443	481
12	488	0	0	N/A	0	0	0	488	969
13	537	0	0	N/A	0	0	0	537	1,506
14	590	0	0	N/A	0	0	0	590	2,096
15	649	0	0	N/A	0	0	0	649	2,745
16	714	0	0	N/A	0	0	0	714	3,459
17	786	0	0	N/A	0	0	0	786	4,245
18	864	0	0	N/A	0	0	0	864	5,109
19	951	0	0	N/A	0	0	0	951	6,060
20	1,046	0	0	N/A	0	0	0	1,046	7,106

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